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V. R. GARDNER, *Director* - - - - - - - - J. G. DUNCAN, *Editor*

THE QUARTERLY BULLETIN

The Quarterly Bulletin of the Michigan Agricultural Experiment Station is issued in February, May, August and November. It presents: (1) progress reports on long-term major research projects; (2) final reports on short-term projects and (3) short, timely articles of a popular nature that bring together information from various sources on subjects in which farmers are interested.

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SELECTIVE CONTROL OF CRABGRASS (*Digitaria* Sp.)[1]

By B. H. GRIGSBY
SECTIONS OF BOTANY AND PLANT PATHOLOGY

DURING the course of certain investigations in 1946 of the effects of solvents on carrot plants, it was observed that some of the materials under test caused injury to small seedlings of crabgrass. This observation led to further work in the search for a compound, or a mixture, which might be effective as a control measure for crabgrass.

Two formulations, L-2687 and L-2988, in greenhouse tests, gave satisfactory control and were tested on lawn plots in the fall of 1946. Young crabgrass seedlings, in an area where other grasses had been destroyed by weed growth, were sprayed with both preparations and were killed within a period of 10 days. In September 1946, lawn plots in which a heavy growth of crabgrass was present, were sprayed. The grass plants were large and flower spikes were already present. Ten days after treatment, all crabgrass was dead, but a few plants of Kentucky bluegrass and quack grass appeared to be uninjured.

Further trials were made is greenhouse flats during the winter of 1946-47. These tests were made to determine the tolerance of annual and perennial plants of the grass group to these chemicals. Flats of commercial lawn grass mixtures were sprayed with the two compounds when the grass seedlings were 2-3 inches in height and no injury was observed. These flats did not develop any crabgrass seedlings but two repeat applications were made at 4-week intervals. The rate of application at each spraying was sufficient to wet all the leaves of the grass plants and was in excess of 100 gallons per acre. None of the grasses were killed but there seemed to be a dwarfing effect upon certain types of grasses in the mixture.

Samples of pure grass seed[2] and cereal grains were obtained and planted in rows in soil containing crabgrass seeds. When the grass seedlings were 3 inches tall, two flats were sprayed with formulation

[1]The work reported here was made possible by a grant from the Standard Oil Company of Indiana.
[2]Supplied by the O. M. Scott and Sons, Company.

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TABLE 1—*Response of certain grasses and cereals to the petroleum base compounds L-2687 and L-2988*

Grasses	L-2687	L-2988
Barley	Killed	Killed
Bent grass	No effect	No effect
Bluegrass, Kentucky	No effect	No effect
Bluegrass, Canadian	No effect	No effect
Brome	Slight red color in leaf sheath	No effect
Corn	Killed in 4 days	Killed in 4 days
Fescue, Chewings'	No effect	No effect
Orchard grass	No effect	No effect
Ryegrass, domestic	Red sheaths	Red sheaths
Red top	Slight stunting	No effect
Sudan grass	Killed	Killed
Wheat	Killed	Killed
Timothy	No effect	No effect

L-2687 at concentrations of 50 and 75 gallons per acre, and two flats were sprayed with formulation L-2988 at concentrations of 50 and 75 gallons per acre. Two other flats were used as checks. The types of grasses used and results obtained are shown in Table 1.

In order to determine the quantity of the compound required to kill crabgrass seedlings, applications at the rates of 25, 50, 75 and 100 gallons an acre were made on plots containing pure stands of crabgrass, 50 plants per flat, at the 3- to 4-leaf stage of growth. A satisfactory kill was obtained at the 75- and 100-gallon rates and no regrowth of sprayed plants occurred in these flats. At the 50-gallon rate, all plants died to the ground level, but weak growth was observed at the base of five plants. At the 25-gallon rate, growth was stopped, but the base of the plants remained alive and regrowth occurred in 2-3 weeks. A second application, 50 gallons an acre, killed all these plants. The effect of the 75-gallon rate of application is shown in Fig. 1.

In July 1947, applications of both formulations were made on crabgrass seedlings in a field which had been plowed but not seeded to any crop. A heavy growth of grass, pigweed, purslane and jimson weed was present in this area. A single application of the petroleum products destroyed the grass seedlings but did not kill any of the broad-leaved weeds.

During July and August, further tests of the petroleum products

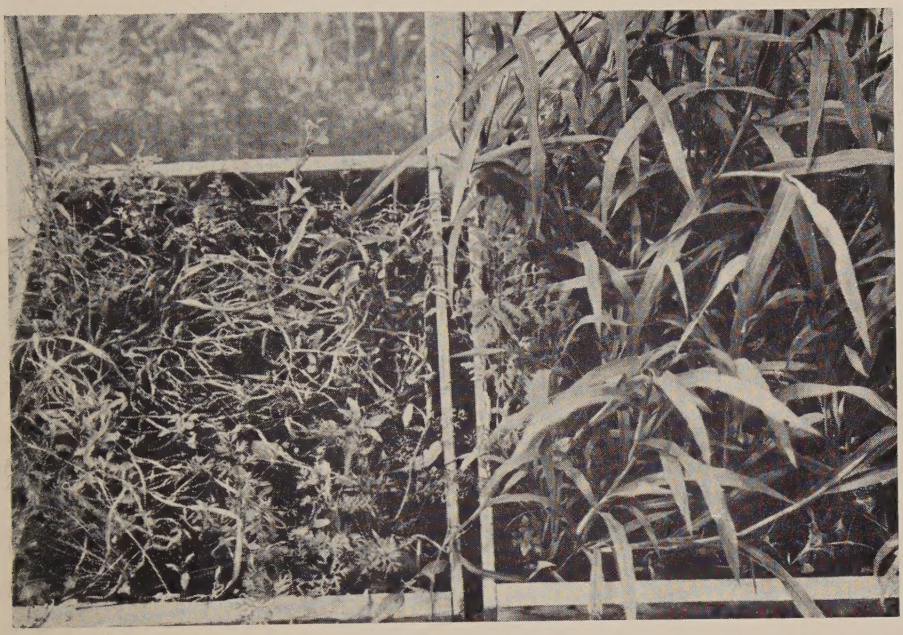

Fig. 1. Effects of L-2687 upon crabgrass. Flat on left sprayed at the rate of 75 gallons an acre, flat on right untreated. Carrots and broad-leaved weeds were not affected by spray treatment.

were made on lawn areas that were infested with crabgrass. The lawn areas were mostly pure stands of Kentucky bluegrass but one test area consisted of 25 percent bluegrass and 75 percent Bermuda grass. The rate of application was 1 quart per 100 square feet. Crabgrass plants at this season were well developed, tillered, and the clumps were 3-6 inches in diameter. In July, the temperature was mild, soil moisture abundant, and a complete kill of crabgrass was obtained in 5-8 days. Bluegrass showed no effects from the spraying, but Bermuda grass developed a slight reddish coloration. This color change, however, was not associated with the death of any leaves.

In the series of plots sprayed during August, when soil was dry and a period of high temperatures and no rainfall prevailed, the same rate of applications gave a rapid kill of crabgrass. It was observed, however, that under these conditions, some injury to the bluegrass did occur. In September, rainfall and lower temperatures brought about a full recovery of the lawn grasses.

Small scale sprayings, at a rate sufficient to wet the foliage, were

made on a number of other grasses and crop plants. Pigeon grass, fox tail, tickle grass, and downy brome grass were killed at any stage of growth by both compounds. Annual bluegrass, quack grass, and stink grass were not affected by either. Beans, field peas, onions, sugar beets, peppermint, gladiolus, and cotton were not affected by direct applications of these petroleum compounds.

During the course of these tests, it was observed that both formulations were toxic to most annual grasses, but the speed of action was somewhat different. Formula L-2687 was more rapid in action and in hot dry weather caused more injury to lawn grasses. L-2988, while slower in taking effect, was about equally effective in killing crabgrass and caused less injury to desirable grasses under unfavorable conditions.

The toxic effects upon crabgrass and other susceptible plants, followed a definite pattern. No effects were visible for a period of 24-48 hours, but later the sprayed plants developed a slight bronzed appearance which changed to a bright purple color in the blade and sheath. These colored plants ceased to grow and, at the end of 5-8 days, began to turn yellow; the leaves died and the stems appeared soft and finally became brown and dry. In the corn plant, the purple color developed in 48 hours, the stems became soft and collapsed, and death occurred within 4 days.

Further studies of the mode of action of these materials are under way, but these observations indicate that some kind of chronic injury occurs in annual grasses which leads to the death of sprayed plants. The characteristic color changes indicate that a disturbance in the translocation of carbohydrate materials occurs and the production of anthocyanin pigment is stimulated. This color change is most pronounced under cool conditions and may not be observed at all in hot dry weather. The effects observed cannot be explained on the basis of an accumulation of oily residue, because both formulations are highly volatile compounds and sprayed plants soon become dry and show no evidence of the accumulation of oil.

The results reported here are from trials under limited climatic conditions, but they indicate that the two compounds possibly have a highly specific toxicity to annual grasses. Similar results in other areas, where different climatic conditions prevail, would establish these materials as useful selective control agents for crabgrass in lawns, turf, golf greens, and in certain crops. This report is given

in order to secure trials under a variety of conditions, the results of which should make it possible to formulate suggestions for the use of the two products as selective herbicides for the control of crabgrass in turf and crop plants.

It is expected that the materials will be available only in small experimental quantities for the 1948 season and for that reason, no suggestions, in regard to dosage nor method of application, are made for the use of home owners or other possible users of the products. The materials offer considerable promise, but further trials are needed and will be made in 1948.

EFFICIENCY IN THE USE OF FERTILIZERS FOR CORN

By L. S. ROBERTSON and R. L. COOK
SECTION OF SOIL SCIENCE

THE DEMAND for fertilizer in Michigan in 1948 will again exceed the supply. For that reason it is doubly imperative that fertilizers be applied for the crops which are most responsive and that methods of application be those most likely to result in the greatest response from a given quantity of fertilizer.

When the supply of fertilizer is equal to the demand, one feels free to recommend the use of as much as economy will permit and for any crop for which there is reasonable assurance that the money expended will be returned. At such a time it may be desirable to recommend fertilizer for some crops which on the average cannot be expected to respond to the fertilizer more than enough to pay the extra expense, since there is always some residual benefit from such an application. On the other hand, the use of fertilizer this year on crops which may not be expected to respond markedly to the treatment may mean that it will be necessary to plant a more responsive crop without fertilizer.

The data obtained from fertilizer and rotation studies on a Brookston clay loam soil in Saginaw County reveal clearly that crops vary in the degree to which they respond to fertilizer. Over a period of 14 years, oats, wheat, alfalfa, and corn have been raised in that sequence, all crops having appeared each year. Several fertilizer analyses have been studied, but the results from 4-16-8 are typical. The oats received 150 pounds per acre, and the yield increase was from 63.6 to 70.2 bushels per acre. Wheat received 250 pounds of fertilizer and yields were increased, as a result, from 25.5 to 33.9 bushels, an increase of 8.4 bushels as compared with 6.3 bushels of oats. Thus, the fertilizer was used more profitably on the wheat than on the oats. Alfalfa followed the wheat without additional fertilizer. The average increase in yield of alfalfa as a result of the fertilizer was 0.71 ton per acre. It has always paid rather well to use extra fertilizer on

ARTICLE 30-48

the crop which is to serve as a nurse crop for alfalfa. Corn has received, in this 14-year experiment, fertilizer at variable rates ranging from 100 to 250 pounds per acre. Most of the applications were at the rate of 100 pounds per acre. The average yield for the 14 years has been 53.7 bushels an acre without fertilizer and 53.2 bushels where fertilized with 4-16-8. To show that it has mattered little what analysis was used so far as corn was concerned, the average yields for six analyses are reported in Table 1. The fertilizer has been applied for corn through the conventional corn planter. Surely these data furnish no evidence to justify a recommendation for the use of fertilizer on corn in 1948.

During the past 20 years over 200 experiments dealing with the fertilization of corn have been conducted on many soil types in 30 counties. In some cases, substantial increases in yields were obtained, but in the majority of the tests the fertilizer did not appreciably increase yields. On some fields, increases in yield were obtained one year but not the next. Because the number of cases of increased yields as a result of fertilizer application has been small and because the results have been inconsistent, the following statement appears in the current issue of the fertilizer recommendation bulletin published by the Michigan State College Extension Service.* "Fertilizer applied with the planter for corn hastens early growth, but usually does not increase yield of grain. Apply fertilizer liberally to small grains, legumes, and other crops preceding corn in the rotation."

In 1941 another experiment on corn fertilization was initiated on the same farm from which came the data in Table 1. It had been observed for several years that corn yielded best when it followed an alfalfa crop. The thought that perhaps it would be possible to fer-

TABLE 1—*Effect of fertilizers on corn yields in an alfalfa, corn, oats, wheat rotation**

Fertilizer analysis	Bushels of corn per acre
0–16–0	53.9
4–16–0	53.5
0–16–8	56.3
4–16–8	53.2
4–16–4	54.3
4–12–4	51.6
Check	53.7

*Average of 14 years data. The soil is a Brookston sandy clay loam. The corn is fertilized at the rate of 100 pounds per acre. The fertilizer is applied with a conventional type of corn planter. The oats and wheat receive 150 and 250 pounds per acre respectively. The alfalfa is not fertilized.

*Extension Bulletin 159.

TABLE 2—*Effect of fertilizing corn indirectly, by topdressing the preceding alfalfa crop with fertilizer**

Treatment	Bushels of corn per acre
1. 1000 pounds 0-12-12 topdressed on alfalfa 125 pounds 4-16-8 in corn row at planting time	50.9
2. Alfalfa not topdressed 125 pounds 4-16-8 in corn row at planting time	49.2
3. 1000 pounds 0-12-12 topdressed on alfalfa Corn not fertilized at planting time	50.4
4. Alfalfa not fertilized Corn not fertilized at planting time	49.7

*Average of 6 years. The corn fertilized at planting time with conventional type planter. This rotation is a corn, bean, barley, alfalfa, alfalfa rotation. The alfalfa is topdressed after the first cutting of the second harvest year. The beans and barley are fertilized with 300 pounds of 0-14-7 and 300 pounds of 4-16-8, respectively.

tilize the alfalfa crop heavily and obtain higher corn yields as a result of the fertilized alfalfa lead to this experiment. The results presented in Table 2 show conclusively that this is not a good way to apply fertilizer for corn.

From the data shown in tables 1 and 2, one might conclude that this land is in such a high state of fertility that fertilizers do no good. Or one might conclude that the variety of corn grown on these plots is not responsive to fertilizer. That this is not the case is demonstrated by the results of the third set of experiments on this same farm.

In this experiment a high-nitrogen fertilizer was plowed down for the corn. The consistency of increased yields is apparent (Table 3),

TABLE 3—*Effect of fertilizer plowed down on corn yields in a corn, corn, soybean, oat, timothy-clover rotation**

Treatments**	Bushels of corn per acre	
	First year	Second year
1. No fertilizer	47.3	35.9
2. Plow down for each corn crop	61.5	51.1
3. Plow down for second corn crop only	46.0	50.4
4. Plow down for each corn crop and planting time application for each crop	61.8	49.2
5. Plow down for second corn crop only and planting time application for each crop	44.4	51.6

*Three-year averages. The soybeans and oats are fertilized with 100 and 300 pounds of 0-14-7, respectively.

**1000 pounds of 8-8-8 is plowed down and 125 pounds of 4-16-8 is applied at planting time with a conventional type of planter.

thus showing that the natural soil fertility was not responsible for lack of response in the earlier experiments and that the variety of corn used on all of these plots does respond to fertilization. The data indicate that in a soil-depleting rotation, such as is practiced in this experiment, it is possible to increase corn yields considerably by plowing down fertilizer, but a summary of all the plow-down experiments conducted over the lower part of the state during the past 5 years show little reason for recommending this practice. Perhaps the increases in yield which have resulted in this particular case are the result of the much greater need for nitrogen in this soil-depleting rotation which is not a rotation commonly used in Michigan. It should be stated at this time that the plow-down attachment affords an easy and rapid method for applying large amounts of fertilizer when one wishes to build up rapidly the reserve fertility of his soil. The data reported in Table 3 show another case where fertilizer applied with a conventional type corn planter did not increase the corn grain yields.

In 1945 a new approach was taken on the corn fertilization problem. It had been shown in previous experiments that fertilizer for beans, peas, and sugar beets should be placed to the side of and below the seed. Most of the fertilizer attachments for corn planters on the market today place the fertilizer in two bands either level with or above the seed. That this placement is not good is indicated by the fact that in most cases higher yields have not resulted from fertilizer applications with these machines.

Accordingly, experiments were started in which fertilizers were placed in bands at different depths below the seed, and slightly to one side of it. As comparisons, treatments were also included in which the fertilizers were plowed under and applied with the conventional planter. The machines for placing the fertilizer at different depths below the seed was constructed by the Division of Farm Power and Machinery of the Bureau of Plant Industry, Soils, and Agricultural Engineering, United States Department of Agriculture. There have been nine experiments in three counties on five soil types conducted to date. The results are promising enough to indicate that if the fertilizer is placed in a similar fashion to that recommended for sugar beets and beans, a consistent increase in yield from fertilizer can be expected.

One of the experiments on fertilizer placement was located on the same farm and in the same 40-acre area with the experiments just reported in tables 1, 2 and 3. The data shown in Table 4 are the

TABLE 4—*Effect of fertilizer placement on corn yields in 1947**

	Treatment	Bushels of corn per acre**
1.	No fertilizer	29.1
2.	Conventional planter—125 pounds of 3-12-12	35.4
3.	Conventional planter—400 pounds of 3-12-12 Experimental planter—400 pounds of 3-12-12.	35.2
4.	Fertilizer level with seed on both sides	35.9
5.	Fertilizer level with seed on one side	35.9
6.	Fertilizer 2 inches below seed on both sides	40.3
7.	Fertilizer 2 inches below seed on one side	37.8
8.	Fertilizer 4 inches below seed on one side	41.6
9.	Fertilizer 6 inches below seed on one side Experimental planter—800 pounds of 3-12-12.	35.1
10.	Fertilizer 6 inches below seed on one side Fertilizer plowed down.	42.1
11.	800 pounds of 8-8-8	34.1
12.	675 pounds of 8-8-8 and 125 pounds of 3-12-12 with a conventional planter at planting time	40.2
13.	675 pounds of 3-12-12 and 125 pounds of 3-12-12 with a conventional planter at planting time	30.7

*Second-year corn in a corn, corn, oats, wheat, alfalfa rotation.
**Difference required for significance at the 5-percent level—7.0 bushels.

results of this experiment. Since these results are for only one year, it is not safe to draw definite conclusions. More investigation on this farm and at other locations will make it possible to make definite recommendations.

The general conclusions to date from these fertilizer placement investigations are: 1) The placement of fertilizer with the conventional corn planter does not produce consistently significant increases in yield. 2) Fertilizer placed in bands to the side of and below the seed gives promise of producing significant yield increases. 3) To date no specific depth can be recommended except that the fertilizer should be placed below the seed. 4) Fertilizer plowed down does not give as good results as does fertilizer placed below the seed at planting time. 5) Fertilizer placed in one band to the side of the seed is as effective as is fertilizer placed in bands on each side of the seed.

SUMMARY

The demand for fertilizer in Michigan in 1948 will exceed the supply. For that reason it is doubly important that fertilizers be ap-

plied properly and for the crops in the rotation which are most likely to respond.

Experiments have shown that sugar beets, beans, wheat, oats and alfalfa are more responsive than corn to applications of commercial fertilizer. The inconsistency in the results obtained from experiments with corn have led to numerous experiments concerning kinds of fertilizer and methods of application for this crop.

Corn has not responded to large quantities of phosphate and potash fertilizer applied on the alfalfa during the summer preceding the plowing of the land for corn. In general, the application of fertilizer through the conventional corn planter has not significantly increased corn yields. A fertilizer high in nitrogen (8-8-8) has, over a 3-year period, caused significant increases in corn yields in a rotation which exhausts the soil nitrogen supply. Consistent and significant increases in corn yields have been obtained when the fertilizer has been placed in bands below and to the side of the seed.

DEHYDRATED POTATOES FOR SWINE

By W. N. McMILLEN, G. A. BROWN and R. W. LUECKE
SECTIONS OF ANIMAL HUSBANDRY AND AGRICULTURAL CHEMISTRY

POTATOES may be dried into meal, flour or flakes containing about 10 percent moisture. In 1944 the United States government in cooperation with the Monitor Sugar Company of Bay City, Michigan, and other sugar and flour mills dehydrated potatoes for livestock feed as one means of disposing of a surplus.

Ferrin (1) in Minnesota trials during the winter of 1942-43 fed lots of 10 pigs, with an initial weight of 65 pounds, potato meal to replace 20, 30 and 40 percent of the corn. He concludes that 1 pound of potato meal is a satisfactory replacement for 1 pound of corn to an extent of 30 percent of the mixture of the two feeds.

Hughes (2) at the California Station fed potato meal at various levels including 10, 25 and 40 percent of the total diet. When potato meal was included in the ration the same amount of barley was taken out. It was fed with tankage, alfalfa meal, salt and oyster shell flour. He concludes that potato meal can logically be fed at a 25-percent level to pigs of all sizes and ages and that 120-pound pigs handle potato meal more efficiently than 50-pound pigs when 40-percent potato meal is used.

Longwell and Buchanan (3) found that dehydrated potatoes could be used to replace up to one-half the corn for fattening pigs without markedly affecting feed requirements. They used pigs averaging 133 and 96 pounds, initial weight, respectively in two of their experiments. This indicates that older hogs are able to use successfully a larger percentage of potato flakes than pigs of lighter weights.

Potato flakes from the Bay City plant were purchased by the College in 1944 and fed to experimental lots of 12 pigs each in the summers of 1944 and 1945.

The potato flakes used had the following composition: moisture—10.48 percent; protein—7.94 percent; ether extract—0.27 percent; crude fiber—2.85 percent; ash—3.56 percent; and nitrogen-free extract—74.89 percent.

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EXPERIMENTAL PROCEDURE

On July 6, 1944, 12 pigs were allotted, placed on rape pasture and were started on a ration of 75 percent potato flakes, 23½ percent protein supplement and 1.5 percent mineral. The protein supplement consisted of equal parts of soybean oil meal and meat scraps. The mineral mixture was made up of equal parts of salt, ground limestone and steamed bonemeal. Owing to severe diarrhea and extremely poor gains this lot was discontinued after 4 weeks.

Another group, Lot 2, was started on the same date on a mixture of corn, protein supplement and mineral. The corn and supplement were mixed so that the pigs received approximately 18 percent crude protein up to 90 pounds in weight, 16 percent up to 125 pounds, and 14 percent to the end of the trial. The average ration consumed is shown in Table 1.

A third group, Lot 3, was handled like Lot 2 except that one-half the corn was replaced with potato flakes. The average ration consumed by the pigs is also shown in Table 1.

Owing to the high feed requirement when 42-percent potato flakes were fed in 1944, a ration was fed containing only 30 percent potato flakes in 1945.

On June 12, 1945, a group of 12 pigs (Lot 4) was placed on rape pasture with access to a ration of ground corn and protein supplement fed free-choice.

TABLE 1--*The influence of dehydrated potato flakes as a replacement for a part of the corn when fed to pigs on rape pasture*

Lot number*....	2 1944	3 1944	4 1945	5 1945
Average ration..	Corn —84.0 Supplement—14.5 Mineral — 1.5	Corn —42.0 Potatoes —42.0 Supplement—14.5 Mineral — 1.5	Corn —89.0 Supplement—10.5 Salt — 0.5	Corn —60.0 Potatoes —30.0 Supplement— 9.5 Salt — 0.5
Average initial weight in pounds	65.0	62.0	44.0	43.0
Average final weight in pounds	202.2	196.6	230.8	215.3
Daily gain in pounds.....	1.49	1.43	1.46	1.37
Feed per 100 pounds gain in pounds.....	391.2	478.4	373.9	367.2

*12 pigs in each lot.

Lot 5 was fed under the same conditions and with the same ration as Lot 4 except that one-third of the corn was replaced with potato flakes.

The average ration consumed by lots 4 and 5 is shown in Table 1. Enough salt was mixed with the protein supplement for these two lots so that the pigs received approximately 0.5 percent salt in their feed.

RESULTS AND DISCUSSION

The average daily gains and feed requirements are presented in Table 1. The pigs fed an average of 42 percent potato flakes (Lot 3) gained slightly less and required 18.2 percent more feed per unit of gain than the control pigs in Lot 2. The pigs in Lot 5, while eating an average of 30 percent potato flakes, made only 0.09 pound less daily gain and their feed requirements were as low as that of their corn-fed controls, Lot 4. These data indicate that 42 percent potato flakes is too high a level and that 30 percent can be fed without increasing feed requirements. In both the 1944 and 1945 trials reported here, the pigs receiving potato flakes made lower gains than their controls until they reached a weight of about 120 pounds after which the gains were approximately the same.

SUMMARY

1. Potato flakes are unsatisfactory for growing pigs when used as the only feed other than protein supplement.

2. When potato flakes were fed as 42 percent of the ration to pigs on rape pasture, feed requirements were increased 18.2 percent.

3. When potato flakes replaced 30 percent of the corn in the ration of pigs on rape pasture, the rate of gain and feed requirements were similar to the controls.

4. In these trials the pigs utilized potato flakes to better advantage after reaching a weight of 120 pounds.

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DEGREE OF RIPENESS AT HARVEST AND PEACH QUALITY AFTER HOLDING

By M. E. CRAVENS, JR., and PAULINE PAUL
SECTIONS OF ECONOMICS AND HOME ECONOMICS

AN IMPORTANT problem in the marketing of peaches is the deterioration in peach quality that begins as soon as the peach ripens and continues rather rapidly during the storage after picking. The tree-ripened peach has less life remaining than one picked at an earlier stage. Before tree-ripened peaches can be marketed successfully, it will be necessary to know the rate at which deterioration in quality occurs with ordinary harvesting methods, and the time required to market peaches commercially. A limited study was made of these factors during the 1946 and 1947 seasons by the Sections of Economics and Home Economics.

Seventeen shipments of Michigan peaches were traced during the 1946 season to learn, among other things, the time they took from packing house to consumer. The marketing time of half-bushel cell boxes and bushel containers of peaches ranged from less than 2 days to almost 12 days, averaging about 4½ days. After purchasing the peaches, the consumers did not use all of them at once but were still using them on the average for 3½ days. This means that the average peach picked on September 20, packed and shipped on September 21, would reach the consumer about September 25 or 26 and that the last peach would be used about September 29—nine days after picking.

On September 20, 1947, peaches of three degrees of ripeness were selected to test change in quality during these average marketing times. These peaches were tested by experienced judges for taste and other quality factors. Tests were made on September 22, or 2 days after picking, and on September 24, 26, and 29. Since the major proportion of the Michigan peach crop is handled without refrigeration, these peaches were held at room temperature (about 70° F.). The qualities scored were those considered by the housewife in determining the acceptability of any given lot of peaches.

ARTICLE 30-50

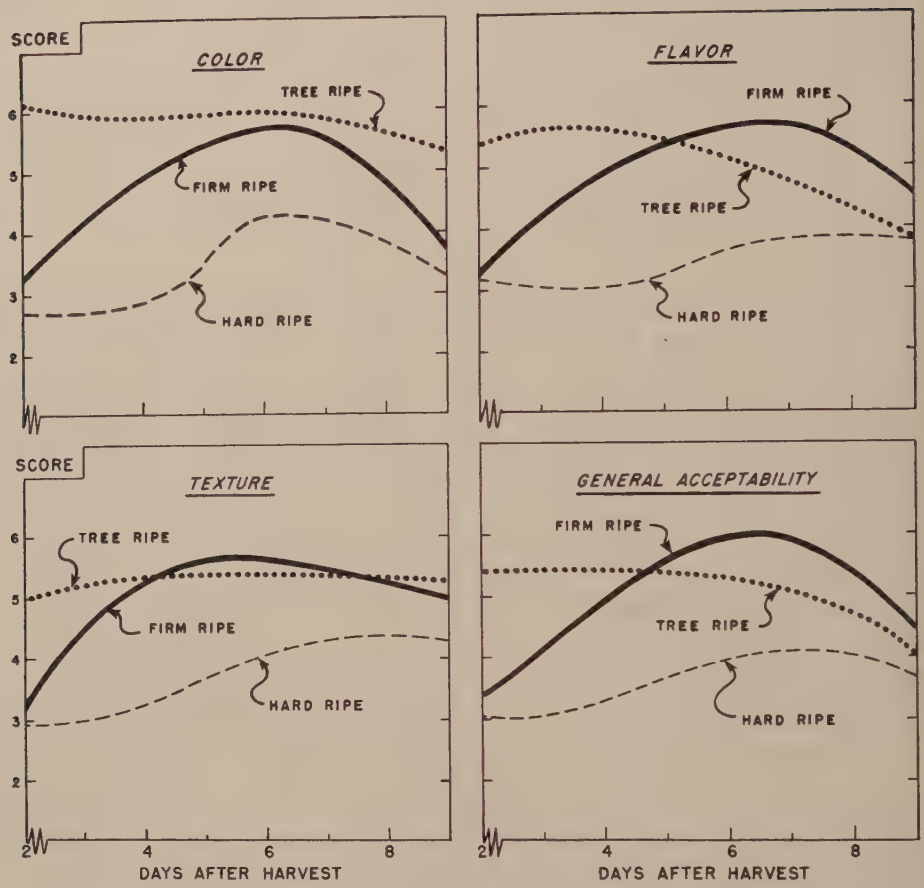

Fig. 1. Effect of holding at room temperature on average scores of quality factors for Elberta peaches packed at different degrees of ripeness (Maximum possible score: 7).*

The results indicated that the tree-ripened peaches were much more acceptable at 2 days after harvest than were the firm-ripe or hard-ripe ones (Fig. 1). At 4 days, the tree-ripened peaches were still slightly more desirable than the firm-ripe peaches. Six days after picking, the firm-ripe peaches were more acceptable than the tree-ripe, and as acceptable as the tree-ripe peaches had been at 2 or 4 days. At 9 days the quality of the firm-ripe peaches was again highest. At no time did the quality of the hard-ripe peaches equal that of either tree-ripe or firm-ripe peaches.

Tables 1 and 2 present data on some of the factors other than

*Scored from sliced peaches.

TABLE 1—*Skin color, incidence of withering and internal browning, and ease of peeling in relation to length of storage of peaches at room temperatures*

Date	Sample	Skin color score*	Withering	Internal browning	Ease of peeling
September 22	tree-ripe	4	none	none	easy
	firm-ripe	2	none	none	difficult
	hard-ripe	1	none	none	very difficult
September 24	tree-ripe	5	none	slight	easy
	firm-ripe	3	none	none	fairly easy
	hard-ripe	2	none	none	difficult
September 26	tree-ripe	5	moderate	slight	easy
	firm-ripe	3	slight	none	easy
	hard-ripe	2	slight	none	easy
September 29	tree-ripe	4	very marked	marked	easy
	firm-ripe	3	marked	slight	easy
	hard-ripe	2	moderate	none	easy

*Skin color scores ranged from 5 for full yellow with considerate red overlay, to 1 for green.

palatability which are important in determining acceptability of peaches. These data confirm, in general, the judges' conclusion that tree-ripe peaches were superior for 4 days after harvest, and firm-ripe peaches were better for storage periods of 6 to 9 days. The firm-ripe peaches did not develop the attractive external color of the tree-ripe peaches, while the hard-ripe peaches were still quite green at the end of the storage period.

This test for one season under the described conditions indicated that the peaches picked at the tree-ripe stage were superior until about the fifth day from harvest after which the quality of the peaches picked firm-ripe was more desirable. It is probable that with temperatures higher or lower than those in the laboratory the rates of change would be different.

The results of this experiment check with sales tests reported by Heckman[1] in St. Paul, Minnesota, where Colorado peaches picked

TABLE 2—*Occurrence of rot in peaches held at room temperatures*

Sample	Total number of peaches in sample	Rotted during storage	
		Number peaches	Percent
Tree-ripe	36	21	58.3
Firm-ripe	34	8	23.5
Hard-ripe	33	5	15.2

[1]John Heckman, "Marketing Colorado Boxed Peaches in the Twin Cities, 1947"; Miscellaneous Report 111, Cooperative Research and Service Division, Farm Credit Administration, Washington, D. C.

at the firm-ripe stage outsold those picked at either tree-ripe or hard-ripe stages.

These results suggest that the marketing of peaches at the tree-ripened stage may result in the supplying of an inferior product to the consumer, if the time interval from harvest to consumption is longer than 5 to 6 days. Altered marketing practices may improve this situation either by shortening the time from harvest to consumption, by introducing storage conditions which will permit holding tree-ripened peaches for longer periods of time, or by promoting the use of firm-ripe peaches for the many conditions where tree-ripe peaches cannot be marketed successfully.

RESULTS OF EXPERIMENTS ON MARKETING RIPER PEACHES

By M. E. CRAVENS, JR., and ARTHUR MAUCH[1]
SECTION OF AGRICULTURAL ECONOMICS

THE WORK at Michigan State College aimed at developing a container to market tree-ripened peaches was begun by T. A. Merrill of the Section of Horticulture in 1942.[2] During 1946 and 1947 the scope of the study has been expanded somewhat, with the sections of Horticulture and Economics cooperating. This is a report of the work by the Section of Economics for these years.

I. PACKAGING

At the outset this problem was considered as primarily one of developing suitable containers for protecting tree-ripened fruit. The years of tests have shown that in addition to containers that will handle tree-ripened fruit there are other and perhaps more difficult problems to be overcome if riper fruit is to become a reality. These other problems will be dealt with in Section II.

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[1]Professor Mauch is Extension Specialist in Agricultural Economics.
Professor H. A. Cardinell of the Section of Horticulture read and made valuable suggestions concerning this article.

[2]In 1944 and 1945 Merrill demonstrated that the cell-type container reduced bruising and made the carrying of tree-ripened peaches possible. His experiments were on a limited scale. In 1946, arrangements were made to try the package in the Detroit stores of The Great A. & P. Tea Company on a commercial scale. It developed that the packing houses were unable, for various reasons, to supply the necessary volume of tree-ripened peaches for as large a test of the container as planned for it. The Millburg and Sodus Fruit Exchanges packed the peaches and cooperated in the 1946 project. H. P. Gaston of the Horticulture Department assisted by Winfred Ettesvold of the Economics Department kept the shipping records, supervised shipments and organized the packing operation. In all, about a third of the intended volume was packed. The authors of the present report observed peach sales in Detroit.

Owing to the difficulties in obtaining tree-ripened fruit in volume during 1946, it seemed advisable to study some of the "bottlenecks" to getting tree-ripened fruit in addition to more detailed information concerning the packing of peaches during 1947. With this in view, the A. & P. Tea Company, the Millburg and Sodus Exchanges and the Horticulture and Economics Sections of the Michigan Agricultural Experiment Station agreed on a limited volume test of tree-ripe peach shipments in 1947. Owing to the unusual season, the only special packages of Elberta peaches shipped were about 150 cartons of 4-quart baskets packed 6 baskets to each "master" carton. These were not tree-ripened peaches. As a result, H. A. Cardinell of the Horticulture Department was able to devote almost full time to the observation and study of the stericooling process, a hydrocooling process using a chlorine-type germicidal agent, "Hypo-clor," in a patented hydrocooler called "The FMC Stericooler". He also placed postcards in several hundred containers of peaches. Lawrence Boger, Robert Kramer and the authors of this report were able to collect the ripeness and yield data and limited sales data.

A separate report on the results of the trials of the "stericooler" on peach rots has been prepared by H. A. Cardinell and A. E. Mitchell. It appears on pages 460 to 467 of this issue of the *Quarterly Bulletin* as Article 30-60, "Packing House Trials to Reduce Peach-rot."

ARTICLE 30-51

TABLE 1—*Reasons for preferring peach container as purchased*

Item	Cell box	Wood box*	Bushel basket
	(percent of total)		
Fewer bruises	57	70	60
Less rot	29	15	20
Easier to handle	9	15	.....
Other	5	.....	20
Total	100	100	100
Number of answers	190	20	5

*2200-inch Michigan box.

Consumer Reaction to Containers

About 400 of the 15,000 postcards placed in containers were returned by peach consumers. This low return was partly due to the fact that many of the peaches were not sold in the original container and the card was designed only for this method of sale.

Consumers logically preferred the container they had purchased, although 98 percent of the cell box purchasers indicated preference for the cell box, and only 82 percent of the purchasers of the tub bushel said they preferred the bushel. The important thing was why they preferred the various containers (Table 1). They were mainly concerned with container qualities that protected the fruit or lessened rot. Over 80 percent of the replies gave these reasons for preferring cell boxes and wooden bushel boxes. Two percent of those purchasing the cell container stated that they did not like it because it was too expensive. The principal dislike stated for the other containers were excessive bruising and waste.

About 60 percent of the buyers of cell containers preferred the ½- to ⅗-bushel unit of purchase, about 35 percent preferred a bushel unit, and another 5 percent a smaller, 4- or 8-quart unit. On the other hand, 16 percent of the purchasers of bushels stated a preference for half-bushel containers.

Reactions to Peaches

Consumers were asked to state the reason for any waste in the peaches they purchased (Table 2). Rots were given by four out of five as the main reason for waste, with most of the remainder blaming worminess.

TABLE 2—*Reasons given by consumers for waste in peaches*

Item	Year		Average
	1946	1947	
	(percent of total)		
Rot	81	81	81
Worms	16	19	16
Crushed	1	.....	1
Too green	1	.....	1
Over-ripe	1	.....	1
Total	100	100	100
Number replies	156	21	177

In the section for remarks several commented on the peaches. In this section "too green" was the most common complaint, making up about 49 percent of the total remarks in 1947 (Table 3). The next most common complaint was that of excessive rots. One customer

TABLE 3—*General remarks on peach cards, 1947*

Item	Number	Percent of answers
Too green	20	49
Rots	5	13
Rot before ripen	3	7
Bruised	3	7
Poor flavor	1	2
Wormy	1	2
Good or excellent peaches	8	20
Total	41	100

in five who answered said that the peaches were satisfactory. These complaints and remarks were of particular interest in a year when rot was as serious as in 1947. In 1946 fewer remarked on the greenness of the peaches.

TABLE 4—*Average days from time peaches were packed to time purchased by consumers and percent waste reported by type of container*

Type of box	Average days from pack to consumer		Percent waste	
	1946	1947	1946	1947
Cell box	3.0	.....	1.9	.....
Bushel basket	5.8	1.9	4.6	7.5
Bushel box	11.5	6.9	5.2	18.7
4-quart box	.....	1.5	.....	0.0*

*This may have been due to replacing of spoiled peaches at the retail store.

TABLE 5—*Distance peaches shipped, days from packing house to consumer, and waste in peaches, 1947*

	Dust treatment	
	Average days	Percent waste
Under 400 miles	3.4	20.0
400 miles and over	9.2	16.0

Waste in Peaches

The reported waste in peaches varied from less than 2 percent for peaches from cell boxes in 1946 to about 19 percent for peaches in wood boxes in 1947 (Table 4). It was not believed that the greater waste reported in peaches in the wood box than in tub bushel baskets was significant. Since the number of days during which these peaches were on their way to these consumers was thought to bear some relationship to the development of rots, this time was also reported. However, the fact that the longer hauls were mostly refrigerated, while the shorter ones were not, apparently offsets the disadvantage of the longer time enroute (Table 5).

One of the more interesting differences in the 1947 experimental shipments was the 2-percent waste reported for stericooled as compared with about 18 percent for non-stericooled peaches. This represented 18 replies from consumers in Florida, Texas, Pennsylvania, Illinois and Michigan.

Utilization of Peaches

About 75 to 90 percent of the peaches purchased by consumers in the original container were used for canning (Table 6). The remainder were sliced or eaten fresh.

TABLE 6—*Utilization of peaches purchased in original containers*

Container	1946			1947		
	Sliced or eaten	Canned	Total	Sliced or eaten	Canned	Total
	(percent)			(percent)		
Cell boxes	18	82	100.0	.....	.....	.....
Bushel basket	26	74	100.0	7	93	100.0
Wood box	20	80	100.0	26	74	100.0

Quality Observations in Retail Stores

About 17 percent of the Halehaven and 14 percent of the Elberta peaches observed in retail stores had rots or other major defects that would have hindered retail sales (Table 7). Rots made up 86 percent of the total defects in the Halehaven and 65 percent of the total defects in the Elberta peaches. Over 60 percent of these rots were found at the stem end. Major bruises made up 12 percent of the Halehaven and 28 percent of the Elberta defects. The fewer bruises in the normally easily bruised Halehaven variety than in the Elberta were mainly due to the large proportion of the Halehaven sample that was marketed in cell boxes. Only 1 percent of the defective peaches in cell boxes were bruised whereas from 4 to 37 percent of the peaches in other bulk containers were bruised. This is a good illustration of the effectiveness of the cell box in protecting the fruit. With peaches retailing at 6 to 8 cents a pound, a container that will deliver from 3 to 36 pounds more of undamaged fruit per hundred pounds of fruit shipped to the store is worth a considerable extra cost.

TABLE 7— *Major defects observed in peaches and percentage of peaches defective in experimental shipments and retail stores, 1947**

Item	Cell box	Tub bushel	Wooden box	4-quart basket	All containers
	(percent of defective peaches with each defect)				
Halehaven					
Rots: Stem end	69	25	49	81	54
Other	29	68	23	5	32
Major bruises	1	4	26	12	12
Worminess	1	.....	1	2	1
Other defects	.....	3	1	.....	1
Total	100	100	100	100	100
Number of peaches examined	1440	377	987	300	3104
Percent of peaches defective	12.3	26.3	19.9	14.3	16.6
Elberta					
Rots: Stem end	.....	42	41	.....	41
Other	.....	32	15	.....	24
Major bruises	.....	19	37	.....	28
Worminess	.....	5	5	.....	5
Other defects	.....	2	2	.....	2
Total	.....	100	100	.....	100
Number of peaches examined	.....	513	605	.....	1,118
Percent of peaches defective	.....	17.2	13.1	.....	13.8

*Any defect that was adjudged noticeable enough to cause sales resistance was called a major defect.

TABLE 8—*Retail peach sales test, Elberta peaches, 1947*

Method of display	Price per pound (cents)	Pounds sold	Percent of total
Bulk—by pound	6.0	667	52
Box with cellophane window (about 2½ pounds)	6.0	434	34
4-quart basket (about 5 pounds)	7.8	175	14
Total	.....	1,276	100

Retail Sales Test

In 1947 a brief sales test was made on consumer packages. This test was run for two hours daily on four successive days in a large retail food market, with the choices shown (Table 8). The peaches in the bulk display and those in the box with the cellophane window were indentical. Those in the 4-quart basket were of the same variety and grade but were not the same lot of peaches. These baskets were packed at the shipping point, while the other boxes were packed at the retail store.

In this experiment the price per pound was the same for the bulk and the box with the cellophane window, but about 2 cents per pound (30 percent) more for the peaches in the 4-quart basket. The store was located in a high-income section in the Detroit area. The bulk lot outsold the other two combined. However, the fact that customers bought about one pound in packages to each pound from bulk displays indicated a willingness on the part of many to try the package.

The results of this test are not conclusive. They do suggest, however, that it is unsound to put too much faith in the sales appeal of packaged over bulk fruit. Unless the package reduces the price or increases the quality of the fruit for sale, it will probably not appreciably affect sales in the long run.

Produce Managers' Reaction

Produce managers in 36 A. & P. stores submitted information concerning peach sales in 1946. These stores handled 10,623 bushel baskets and 887 cell-type containers, the latter having a capacity of approximately ⅗ bushel. The cell box contains four layers of 24 peaches, or a total of 96 peaches. About one-eighth of the cell-packed peaches were sold by the pound in small lots. In one store all of the

Fig. 1. Packing peaches in the experimental 4-quart basket. It was found that the peaches had to be "placed", in order to insure a full pack that could be shipped successfully in the master carton.

26 cases received were sold in this way. In some stores this method of sale was due to the better condition of the cell-packed peach, and in others due to the consumer resistance to the package.

The total loss, in 30 stores reporting loss, owing to reduction in price or discarding of soiled peaches, amounted to nearly 4 percent of the retail value of the peaches. Estimates indicated that nearly 12 percent of the bushel baskets suffered a mark-down in price due to over-ripeness, bruising, market price changes, or week-end clean

up. Price reductions for the cell box occurred in only some over 4 percent of the cases.

The managers said that the quality of peaches in 1946 was generally good, and most buyers commented that it was the best in years. A few complained of clingstones. Many customers said they would have bought more except for the lack of canning sugar.

Of the 36 managers, 13 reacted very favorably toward the cell-type box, and an additional 14 were favorable toward it with certain reservations. Some said it would take a little time to educate the consumer to its merits. Some added that the fruit should be riper than in the bushel baskets, while a few said a half-bushel box would be "swell," but no more 96-peach or ⅗-bushel containers. A few thought that a cell bushel would be a good seller. Seven managers definitely were dissatisfied with the cell box, and two had no comment.

Each manager was asked if he preferred the bushel basket only. Of course, the seven who were opposed to the cell box preferred the bushel basket only. In addition, five others answered this question in the affirmative. Eight of these 12 said the customers were better satisfied with the conventional package or that there was customer resistance to the cell box. Other reasons mentioned were that a better mass display could be attained and the bushel basket was a better volume getter.

Nineteen produce managers preferred a combination of the bushel basket and the cell box. Four of these liked the cell box because it helps to maintain quality of the peach longer, and another said, "they sell good by the pound," which is another way of saying they were of better quality than those in the baskets. Three stated that the bushel was too large for small families and apartment dwellers, and three others said, "the more variety, the more business." Eight gave no reason for preference for both the cell box and the bushel basket. Five managers did not answer this question.

Following are the comments of one store manager concerning the 1947 experimental packages: "I believe the two-pound package is all right; however, this year, as you know, was not a fair trial. The peaches would not hold up long enough to assure good merchandising. For this package the merchandise must be of the best. Without a doubt the half-bushel cell pack is the very best. Of course, we must have the 4-quart basket also to sell to those wanting more than 2 pounds and less than a half-bushel.

"The peaches received in the western box were in much better condition than the bushel basket peach. They had 'class' or 'distinction' compared with the bushel basket."

Summary and Conclusions on Packaging

In 1946 the cell boxes were retailed at $2.09 and bushel baskets at $2.89. Hence, a premium of about one cent a pound was asked for the former, although in some cases there was little difference in ripeness when packed. The peaches were larger and more uniform in size than those in other containers. Two cell boxes cost about 20 cents more than a bushel basket. In addition, a premium of 10 cents a box was charged for extra packing costs. The packing houses were not set up to handle the cell box efficiently, and only about 10 percent of the peaches woud fill the 2-⅝ inch cells; consequently, though it was expected that up to a thousand cartons would be packaged daily for 10 days, an average of fewer than 300 were packed. Stopwatch studies by H. P. Gaston indicated that peaches can be put up in cell-type containers just as rapidly as they can be packed in bushel baskets or western boxes. Putting up fruit in this way probably will not add to the expense if packing house lines are set up to handle this package and if suitable sizes of cells are available.

The principal value of the cell-type package lies in its ability to carry relatively ripe peaches better than other packages now in common use. The interval between full maturity and heavy loss due to over-ripeness is so short that a large part of Michigan's commercial peach crop is harvested and packed while the fruit is in the "hard ripe" stage. Hard-ripe peaches do not particularly need the protection afforded by the cell-type package; and inasmuch as such packages are relatively expensive and do not display the fruit to good advantage, it is questionable that such packages will come into widespread use as long as peaches move through existing channels of trade and under existing methods.

Advantages of the Cell-Pack

The ability of the cell-pack to protect the fruit from bruising and to aid in preventing spread of brown-rot was not so significant in 1946. That year brown-rot was not a major problem because of the dry season.

No Elberta peaches were shipped in the cell boxes during 1947. Other tests showed that a large part of the rot infection of sound peaches comes from contact with infected ones. This package eliminates the contact between peaches.

Another advantage is that the cell-pack affords small families and apartment dwellers an opportunity to buy less than the bulky, unwieldy bushel basket which is hard to carry and store in the home. Furthermore, peaches will hold quality longer in the individual cells and there is less urgency to process quickly.

Cell boxes are handled easily and stacked efficiently, and carry the weight of the load well if not stacked more than 5 or 6 high. Experience reveals that even when the carton is crushed considerably in the lower tier the fruit shows no visible damage.

Disadvantages of the Cell-Pack

Cell boxes are relatively expensive. They cost about 20-25 cents more per bushel than tub bushel baskets.

The cell box requires sorting of peaches to a size that will fill the cells. Even then there seems to be an excess of paper.

If the fruit is not sufficiently ripe or lacks color, the cell-pack accentuates the lack of color.

Cell boxes do not lend themselves to an attractive mass display such as is possible with the bushel basket. However, this probably could be improved with some experience and with more packages per store.

There is always consumer resistance to a new package. In spite of variation in quality and weight and the high price, however, consumers in general expressed satisfaction with the cell-pack. With quality fruit and consumer education, this resistance can be eliminated. With lower consumer incomes, however, it may be more difficult to attract buyers if a premium price is necessary. This difficulty was reported by produce managers in stores located in low income areas in 1946.

Recommended Improvements

The cell-type package would be improved if the paperboard units which make up a tier of cells were made so that they would cling together more firmly. Many of those supplied this year fell apart as

they were handled. Packers spent considerable time reassembling cell units.

Cell-type packages should be ventilated. Those for use in 1947 were ventilated.

The cell-type package would be better if the cell unit used to protect the fruit in the top layer were re-designed in such a way that it would show the fruit to better advantage.

The cells should be designed to hold small as well as large peaches and the number of cells adjusted to obtain a true half bushel.

II. OTHER FACTORS AFFECTING RIPENESS OF PEACHES MARKETED

This part of the report is a summary of some items of information having a bearing on the problem of marketing ripe peaches, but is not a part of the packaging study. Until more complete data are available on some of these factors, the developing of packages alone will not solve the problem.

Normal Seasonal Peach Price Movements

An analysis of Elberta peach prices at the Benton Harbor Market for the 1938-42 and the 1943-47 seasons shows a very distinct seasonal

Fig. 2. The Benton Harbor Market over which about 1,293,000 bushels of peaches were sold during the 1947 season. Buyers on this market had their choice of several degrees of ripeness. Most peaches were packed in bushel baskets.

pattern (Fig. 3).[1] Since the 1943-47 period was greatly affected by price controls, more weight has been given to the pattern during the 1938-42 seasons. During this period peach prices rose until about seven marketing days before the peak peach sales through the Benton Harbor Market. Prices then fell until 2 to 4 days after the largest days volume of peach marketings through the market. After the low point in prices, they rose for about 11 days to a new price peak. This peak came slightly later than 2 weeks after the heaviest Benton Harbor sales period. During the prewar years 1938-42, prices were higher towards the end than at the beginning of the season. The reverse was true for the 1943-47 average. Wide variations from these patterns occurred in individual years.

If we use $1.50 as the season average price for Elberta peaches on

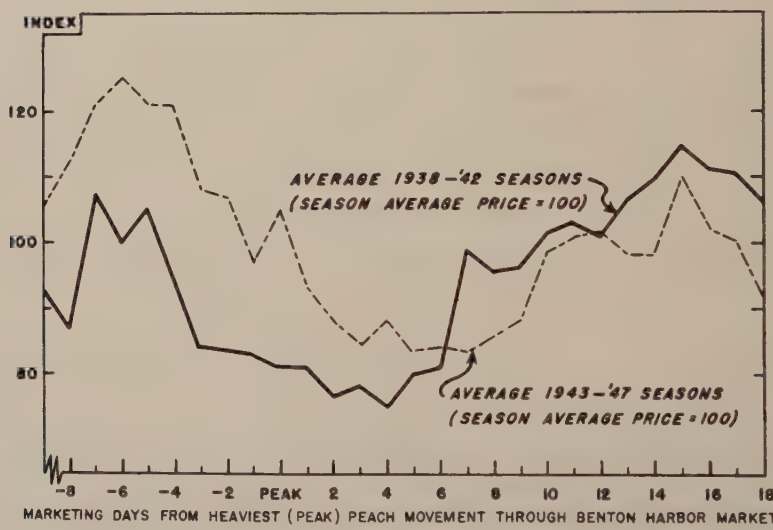
INDEX
120
100
80
AVERAGE 1938-'42 SEASONS
(SEASON AVERAGE PRICE = 100)
AVERAGE 1943-'47 SEASONS
(SEASON AVERAGE PRICE = 100)
-8 -6 -4 -2 PEAK 2 4 6 8 10 12 14 16 18
MARKETING DAYS FROM HEAVIEST (PEAK) PEACH MOVEMENT THROUGH BENTON HARBOR MARKET

Fig. 3. Seasonal variation in the price of Elberta peaches over the Benton Harbor Market, 1938-42 and 1943-47 seasons.* The bulk of the Elberta peach movement through the Benton Harbor Market comes during the 2-week period from 6 days before to 8 days after the peak peach movement (the middle day during the heaviest week's sales). During the latest 5-year period the price rise from the seasonal low point until near the end of the season was less than in 1938-42.

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*Data from annual summaries of Benton Harbor Market News Report—U.S.D.A., Production and Marketing Administration, and Michigan Department of Agriculture. Unweighted average of daily prices for season = 100.

[1]Since the peach marketing periods came at widely different calendar dates in different years, the five season averages were obtained by using the day with the heaviest peach sale through the Benton Harbor Market as the base date each year to "center" the season and tabulating prices for each marketing day before and after these bases. A simple average of relatives was used to combine the 5 years.

the Benton Harbor Market, (average 1938-42 = $1.57), peach prices reached a peak of about $1.65 a bushel early in the season, fell in 7 to 10 marketing days to about $1.20 per bushel, then rose in 11 marketing days to about $1.79 late in the season.

In 1946 approximately three-fourths of the Elberta peaches sold through the Benton Harbor Market moved during the declining price period. Most of the other one-fourth moved during the period of rising prices later in the season. In other words, during the rush of the bulk of the peaches to market the price was declining at the rate of 4 to 5 cents per marketing day.[1] Under such conditions it is understandable why growers feel that they cannot afford to ripen peaches two or three extra days when their fruit has the necessary size and grade for selling. As long as dealers will pay premium prices for immature peaches, they will get them. For those growers whose peaches will not reach the necessary standard of maturity before the low point in prices, there seems to be a double advantage in marketing at somewhat more than average ripeness. They sell a larger volume on a rising market.

Attitude of the "Trade"

The fact that the practice of buying "green" peaches is almost universal suggests that there must be a reason for it. One good reason frequently heard is that "I've never lost any money on green peaches but I have on ripe ones." Not enough has been done to find out why wholesalers and retailers stock up on "green" peaches to the apparent displeasure of their customers and the detriment of later sales. A complete answer to why this is done would go a long way towards explaining why riper peaches are not marketed. It is possible that the various dealers do not realize the extent of the harm to retail sales this practice causes. The effect of these "green" peaches on consumer demand could and should be studied. There is every reason to believe that if evidence on sales and profits can be shown to favor the sale of riper peaches, dealers would attempt to sell them.

Length of Marketing Process

In a check of 17 shipments during the 1946 season it was found that the trip from the packing house to consumer took from 2 to 12 days and averaged about 4½ days. Consumers were still using the

[1]The rate of decline for the steepest 7-day period was about 4 percent (6 cents per bushel) per day in 1938-42, and for the steepest 9-day period in 1943-47 it was 4½ percent (7 cents per bushel) per day on the basis of $1.50 peaches.

fruit for 3½ days after purchase, on an average. This meant that peaches picked on the afternoon of September 20 and packed and shipped on September 21 would reach the consumer about September 25 or 26 and that the last peach would be used September 29. Dealers would undoubtedly like to shorten this period. Some chains and others in nearby markets have reduced the time from packing house to retail store to one day, but this is not possible for all dealers and areas. Peaches are mostly picked to stand up under the maximum average shipping time rather than on the basis of the length of marketing period expected for nearby consumers and distant consumers. An organization with a distribution system geared to handling peaches in 3 days from the packing shed is understandably reluctant to handle peaches that begin to deteriorate rapidly at 3 days. They need some margin of safety in case sales are slow. In this connection a great deal more technical information is needed on the rapidity of ripening and deterioration of green-ripe, firm-ripe, and tree-ripe peaches under normal and under refrigerated temperatures. With detailed and reliable information of this type, a distribution organization can begin to work out methods to market peaches of a more satisfactory degree of ripeness.

Control of Rots

Rots are a greater problem in tree-ripened peaches than in peaches shipped at the usual ripeness. The main reason for increased rots is the longer period during which the peach may become infected and rot. Until rots are controlled, both in the orchard and in the packing house, the shipment of tree-ripe peaches in years of bad rot infection is likely to be small even though all other problems are solved.

The fact that about 60 percent of the rots recorded in retail store tests were at the stem end indicates a possibility that the weakest link in rot control is during the period immediately after harvest when the infection apparently enters the peach through a picking injury. It is usually easier and safer to prevent an infection than to allow infection to develop and then attempt to stop its growth. This would mean more prompt treatment for rot control after picking. Because of the rapid rate of spread of these rots, this may mean treatment within an hour or two instead of after the common overnight wait.

The "stericooling" process described in the footnote on page 387 was tested for the first time in Michigan in 1947 and offers consider-

Fig. 4. Lawrence Boger pointing out to Bill Voight and Forrest Steimle the reduced yield obtained in the Steimle Brothers orchard when peaches were picked at the hard-ripe instead of tree-ripe stage.

able hope of more effective rot control in the critical period after harvest. Several experimental shipments of peaches treated with this process were made in 1947.[1] Of those shipments checked by post-card customers reported about 18 percent rot in the dust-treated peaches compared to about 2 percent for those in stericooled lots. The sulfur dust treatment in connection with the defuzzing operation is a standard treatment for rot control in Michigan.

Stericooling apparently arrests the ripening processes in the peach as well as helping prevent rots. This would permit the harvesting and marketing of riper peaches regardless of its effect on rot control.

Aside from the question of stericooling there are still differences of opinion among members of the trade on the effectiveness in rot

[1]H. A. Cardinell, Horticulture Department, Michigan State College, and C. G. Barr, of the John Bean Division of the Food Machinery Corporation, Lansing, conducted these tests.

control of such practices as precooling and refrigeration for short hauls. Many dealers believe that precooling increases rather than decreases rot breakdown on short hauls. The answers to some of these questions may be available in present experimental data. For those questions where this is not the case, further tests under ordinary trade conditions as well as under laboratory conditions are needed.

Ripeness at Harvest and Yield

There is some experimental evidence of remarkable increases in yield due to ripening of peaches beyond the usual picking date. In connection with the shipping tests two experiments were conducted to check yields under normal and tree-ripened harvest conditions.[1]

In one experiment 101 trees were picked at the usual stage of ripeness and 101 adjoining trees were picked at the tree-ripened stage (Table 9). It was found that harvesting at the usual ripeness yielded 230 bushels, while the tree-ripened trees yielded 272 bushels or about 18 percent more.

TABLE 9—*Yield tests—hard-ripe compared with tree-ripe peaches, Berrien County, Michigan, 1947 season*

Halehaven (Steimle Orchard—36 trees)			Halehaven (Randall Orchard—82 trees)			Elbertas (Steimle Orchard—84 trees)**		
Picking date	Hard-ripe	Tree-ripe	Picking date	Hard-ripe	Tree-ripe	Picking date	Hard-ripe	Tree-ripe
	(bushels)			(bushels)			(bushels)	
Sept. 5	19.5	.....	Sept. 4	18.0	.....	Sept. 17	4.0	.....
Sept. 8	.....	6.5	Sept. 8	59.0	46.5	Sept. 20	45.0	.....
Sept. 11	12.0	14.0	Sept. 10	.....	47.0	Sept. 22	.....	30.0
Sept. 13	.....	10.5	Sept. 12	36.0	44.0	Sept. 30	36.0	49.0
						Oct. 3	.....	24.0
Total	31.5	31.0*	Total	113.0	137.5	Total	85.0	103.0
TOTALS							229.5	271.5

*Mr. Boger estimated that 10 percent of the peaches were not harvested because of brown rot infection. This was not as important in the hard-ripe harvested trees.

**About 10 peaches per tree fell from the tree-ripe and other trees in the eight days following the September 21 storm. From 4 to 15 peaches were left on the trees after the last picking. This seemed to be general through the orchard, as the foliage was very heavy and beginning to turn yellow by the end of the harvest.

[1]By Lawrence Boger and Robert Kramer, graduate students, Economics Department, Michigan State College.

Forty-two of the trees were Elberta and 59 were Halehaven. Three pickings were made for each degree of ripeness except for one block of 18 trees picked only twice. It took an average of 5.8 minutes per bushel to harvest each of the 230 bushels of hard-ripe peaches and 5.7 minutes per bushel to harvest each of the 272 bushels of tree-ripe peaches.

The yield increases and harvest labor did not tell the whole story, however, for where about 7 percent of the peaches of usual ripeness were noticeably bruised by the time they reached the packing house, one-third of the tree-ripened peaches were so bruised. About a fourth of the tree-ripened peaches that were sound when they arrived at the packing houses were bruised by the present grading machinery where a much smaller percentage was noticeably bruised in peaches of usual ripeness. Once through these harvesting and grading hazards, several shipments were successfully marketed in special cell-box cartons and in wooden bushel "spruce" boxes.

With the present handling and marketing methods only a limited volume of peaches can be marketed successfully at the tree-ripened stage. In the future with more efficient and immediate processing use of peaches too ripe or too bruised to pack well, it may be possible to pick and market a large proportion of the crop at a riper stage. Sales tests have indicated that the principal bottleneck is not the lack of consumer demand for riper peaches, but rather the lack of technical "know how" to produce and handle them. With the harvest of a riper peach there will be a need for utilization of a larger volume of peaches that will become too ripe to pack. Some shippers are making use of these for freezing or canning. Possibilities of increasing such uses should be explored.

In the latter part of this experiment, 42 Elberta trees were picked at the usual ripeness and 42 trees at tree-ripe stage. By the time of the storm on September 21 about 57 percent of the peaches were picked from the trees where normal methods (ripeness) were used and less than 2 percent from the tree-ripened trees. The drop loss caused by the storm was accurately checked for the trees being picked at the tree-ripe and the hard-ripe stages. This showed that the "tree-ripe" trees lost about 4 percent, while the hard-ripe ones lost about 3 percent of their total yield.[1] In other orchards where the storm was more severe, the drop losses were much heavier.

[1]Based only on the peaches left on the trees (43 percent left on hard-ripe and 98 percent left on tree-ripe trees), the tree-ripe ones lost about 4 percent and the hard-ripe lost about 7 percent.

Fig. 5. The end of the grading table and the peach sizer. It is at this stage in the commercial packing operation that much of the bruising of soft peaches occurs.

In another phase of this experiment the size and degree of ripeness of 12 Elberta peaches on four different trees were measured for 14 days from the time they were considered mature until tree-ripe. These peaches were tagged and daily measurements of circumference were made with a flexible steel tape. These peaches grew about 20 percent in size (volume) during the period from hard-ripe to tree-ripe peaches. This should be compared with the 20 to 30 percent price decline that normally occurred between the beginning of the volume movement and 3 to 4 days past the peak in volume harvested. About half this swelling occurred during the first 3 days, with the remainder during the next 9 days. The storm on the afternoon of September 21 (on the third day of these measurements), with the cool weather following it, may have slowed peach growth considerably.

A comparison of the growth of these peaches between degrees of ripeness, as indicated by appearance, showed that about half of the increase in size occurred between the time they were adjudged hard-ripe and the start of the firm-ripe stage. The remaining swelling oc-

curred between the beginning of the firm-ripe and the beginning of the tree-ripe stages. Thus, about 50 percent of the swelling over that occurring by the normal picking stage had taken place by the time the peaches were firm-ripe. At Illinois, Dorsey and McMunn showed slightly greater volume increases than those reported here. They concluded that growers could take advantage of most of this increase in size by picking at a firm-ripe stage or later.[1]

A Reliable Test for Ripeness

During the yield tests the plots were visited daily in order to determine ripeness and/or to record the data on peach growth. In spite of this close attention, a large part of the tree-ripe pickings were too ripe to handle successfully. Some of the supposedly "normally" ripe Halehaven peaches were more nearly firm-ripe than hard-ripe. This illustrates a major problem. Until and unless a reliable measure of ripeness suitable for use by pickers is developed, the picking of a peach of a given degree of ripeness will be a hit-or-miss proposition. There is no satisfactory standard test for ripeness in general use even in laboratory work. Even if such an indication of ripeness cannot be developed at once, there is much to learn through studies of the methods of growers who are successful in producing and picking peaches of a uniformly satisfactory ripeness.

Conclusions

There is room for a great deal of laboratory experimentation before or in connection with further experimental marketing of tree-ripened peaches. With adequate answers to the physiological reactions of peaches under varying conditions, dealers would be able to handle and growers would be able to market riper fruit. There is still considerable progress to be achieved, so far as ripeness is concerned, in marketing a true firm-ripe peach, let alone a tree-ripe one. An immediate aim of marketing more firm-ripe peaches would be more feasible from the producers' and dealers' standpoint and might better satisfy the consumer than the so-called "tree-ripened" product.

In the immediate future there are at least eight types of information that need to be obtained if marketing agencies and growers are to deliver appreciable quantities of riper peaches to consumers.

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[1]M. J. Dorsey and R. L. McMunn, Bulletin 507, "Tree Conditioning the Peach Crop," University of Illinois Agricultural Experiment Station, Urbana, Ill.

1. How ripe does a peach need to be when picked if the highest quality is to be preserved to consumers in 2 to 8 days or highest "market" quality? Is it possible through temperature control to pick peaches before the tree-ripe stage and have tree-ripe quality in 4 to 6 days? What proportion of the final swelling comes before the peak in market quality?

2. Does the practice of dealers in stocking up on "green" peaches slow sales as much as is commonly believed? If this practice decreases sales, why do dealers persist in the practice? In what ways can they be encouraged to handle fewer "green" peaches?

3. To what extent can the marketing period be shortened? To what extent can individual dealers benefit by gearing the ripeness of the peaches they purchase to the expected length of the marketing period?

4. How can rots in peaches be prevented or be controlled?

5. What are the best uses for peaches too ripe to ship? With riper harvesting of peaches there will be greater need for uses for those too soft for packing.

6. In what ways can the added risks of price declines, over-ripeness and drops be insured against or predicted so that the individual grower can better judge whether to pick peaches at a riper stage?

7. Develop a reliable "field" test for ripeness. Also develop a reliable and usable packing house test for ripeness to sort peaches on the basis of ripeness before packing.

8. Continue to develop and test packages with the aim of reducing package costs and increasing peach protection and consumer acceptance. Develop packing machinery to handle riper peaches.

NEW FUNGICIDES FOR TOMATOES

By M. C. STRONG
SECTION OF BOTANY AND PLANT PATHOLOGY

THE YIELD of marketable tomatoes produced in Michigan is reduced nearly every year by attacks of three leaf diseases commonly called "blights". These diseases are early blight caused by *Alternaria solani*, Septoria blight caused by *Septoria lycopersici*, and late blight caused by *Phytophthora infestans*.

Of these three diseases, the last named is by far the most devastating because it spreads rapidly and kills entire plants under favorable weather conditions such as prevailed in the eastern and central states in 1946 when heavy losses were sustained. The other two blights usually progress more slowly and result in a gradual defoliation (Fig. 1) which reduces the fruit-producing capacity of the plant and subjects the fruits that are produced to sunscald and other injuries. Fruits thus exposed to direct sunlight usually fail to produce a good red

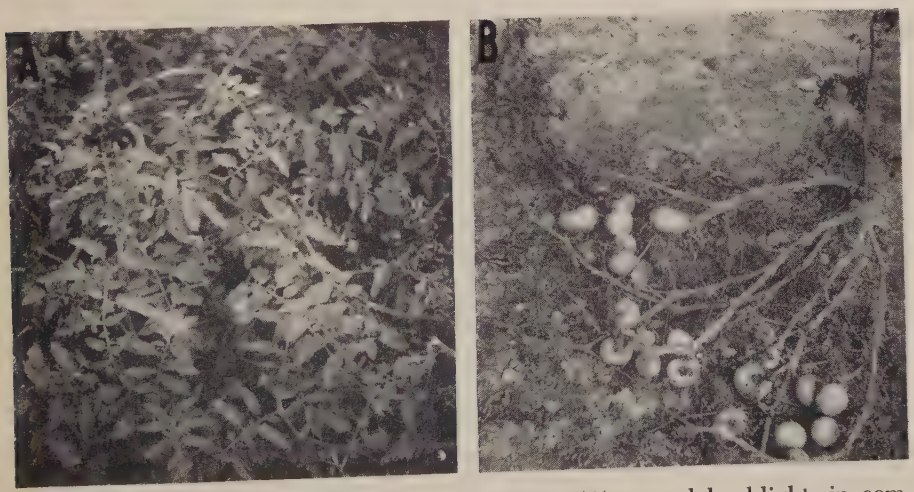

Fig. 1. Showing defoliation of tomato plant (B) caused by blight, in comparison with healthy plant (A) protected from infection by applications of a fungicidal spray. Note exposed fruit (B) which are affected with sun scald and rot.

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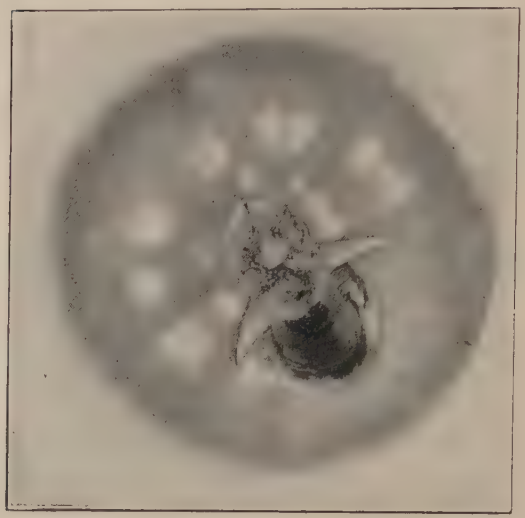

Fig. 2. Showing tomato fruit affected with Alternaria rot, a common result of early blight infection.

color, the lack of which reduces their grade. Early and late blight fungi also produce characteristic fruit rots (Fig. 2) which increase the percentage of culls.

Another disease which enters into this production picture is anthracnose, a ripe fruit spot (Fig. 3) caused by *Colletotrichum*

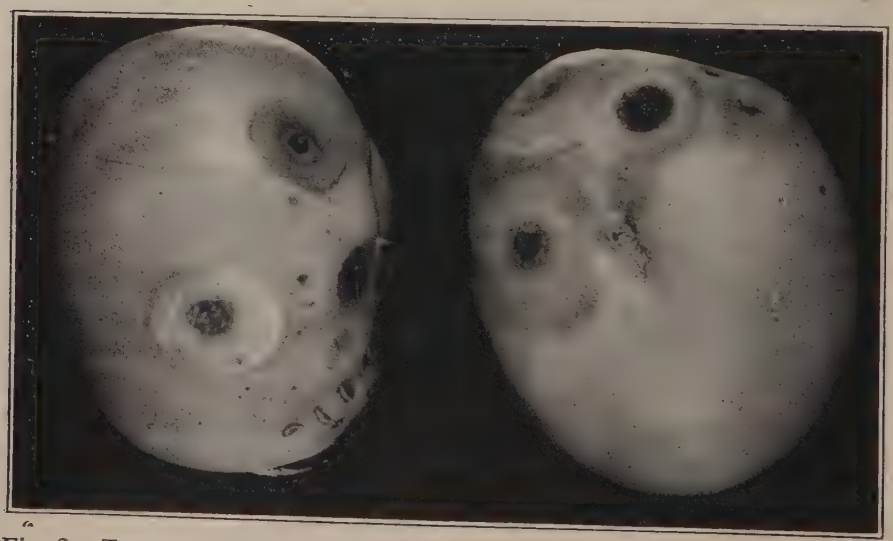

Fig. 3. Tomato fruit infected with anthracnose, a ripe fruit spot caused by Colletotrichum phomoides.

phomoides. This trouble also reduces the grade of fruit, and is often prevalent on late canning varieties that are left to ripen on the vine.

In the past, the standard treatment for these troubles has been timely applications of a copper spray or dust. However, in the last 5 years many new fungicides have been developed. Several of these new materials have been tested on tomatoes and compared with various copper fungicides. The results of these trials are here reported. The materials tested, their manufacturers, and rates of application are listed in Table 1.

TABLE 1—*Spray materials tested*

Trade name	Fungicidal chemical	Manufacturer	Rate of application
Bioquin 1	copper-8-quinolinolate	Monsanto Chem. Co.	1 lb.—100 gal.
Bordeaux mixture	copper sulfate	homemade	8 lb.—100 gal. plus 8 lb. lime
Copper zinc chromate	copper zinc chromate	Carbide and Carbon Chem. Corp.	4 lb.—100 gal.
Cuprocide	copper oxide	Rohm and Haas Co.	2.4 lb.—100 gal.
Dithane 14	disodium ethylene bis dithio carbamate	Rohm and Haas Co.	2 qt.—100 gal. plus 1 lb. zinc sulfate and ½ lb. lime
Dithane Z78	zinc ethylene bis dithio carbamate	Rohm and Haas Co.	2 lb.—100 gal.
Fermate	ferric dimethyl dithio carbamate	E. I. duPont Co.	2 lb.—100 gal.
No. 341	2 heptadecyl glyoxalidine	Carbide and Carbon Chem. Corp.	1 gal. —100 gal.
Omilite	polyethylene polysulfide	Goodrich Rubber Co.	2 qt.—100 gal.
Parzate	zinc ethylene bis dithio carbamate	E. I. duPont Co.	2 lb.—100 gal.
Phygon (wettable)	2, 3 dichloro napthoquinone	U. S. Rubber Co.	2 lb.—100 gal.
Puratized	phenyl mercuric triethanole ammonium lactate	Gallowhur & Co.	1 pt.—100 gal.
Tss wax emulsion	none	experimental	

METHODS

Southern-grown tomato plants were used in these tests because it is the common practice of many processing companies to furnish such plants to their growers. In 1945 the variety planted was Early Baltimore; in 1946, Rutgers; and in 1947, Wisconsin 55. Randomized plots were laid out in a field where tomatoes had been grown the year before and leaf diseases had been present. In addition, the soil was infested with the causal fungus of anthracnose by raking in cooked grain on which this organism was growing.

In 1945 and 1946 there were 26 plants per plot and in 1947, 24 plants. Plots were always replicated four times. Plants were set 3 feet apart in the row, and rows were alternately 3 and 6 feet apart, leaving ample space for the passing of spray equipment.

The first spray was applied when the first cluster of fruit was well developed or about the middle of July. Five applications were made at 2-week intervals which carried the spray program into September. Sprays were applied with a power sprayer of wheelbarrow type at 200 pounds pressure.

In 1945, Alternaria and Septoria blights were present, while in the last two seasons only Alternaria blight appeared. No late blight was observed. There was a slight amount of anthracnose infection in 1945.

In 1946, additional tests were conducted on the Elwyn Isley* farm in Lenawee Co. The variety planted was Pritchard, and the plots were approximately three-fourths acre in size. Sprays were applied with power equipment mounted on a truck. Five applications were made at 10-day intervals, beginning at the time of setting of the third cluster of fruit. The prevalent disease in these plots was Septoria blight. Some anthracnose appeared late in the season. Defoliation and anthracnose counts were made but yield data were not obtained.

RESULTS

At East Lansing ripe fruit were picked at weekly intervals, graded and weighed. Yield data were based on weight of marketable fruit. Data on anthracnose control were based on percentage of culls due to this disease. Blight control estimates were based on defoliation counts made in September.

Because the 1947 season was very short, the yield was only one-third to one-half as large as normal. This makes it very difficult to compare 1947 yields with those of the other two seasons. Consequently, instead of enumerating the yield data secured, the spray materials tested have been rated from best to poorest on the basis of yield and also blight and anthracnose control for the three seasons. This rating is shown in Table 2.

*The author wishes to express appreciation to Mr. Isley for his cooperation in these tests.

TABLE 2—*Rating of spray materials tested, from best to poorest on the basis of yield, blight and anthracnose control*

Year and location of test	Yield	Blight control (Alternaria, Septoria)	Anthracnose control
1945 East Lansing	1 Cuprocide 2 Fermate 3 Bordeaux 4 Untreated 5 Wax emulsion	1 Bordeaux 2 Cuprocide 3 Fermate 4 Untreated 5 Wax emulsion	1 Fermate 2 Cuprocide 3 Bordeaux 4 Untreated 5 Wax emulsion
1946 East Lansing	1 Tribasic copper 2 Zerlate alternating with tribasic copper 3 Zerlate 4 {Phygon* No. 341 5 Fermate alternating with tribasic copper 6 Dithane 14 7 Fermate 8 Untreated 9 Bordeaux 10 Omilite 11 Puratized	1 Bordeaux 2 Tribasic copper 3 Dithane 14 4 Phygon 5 Zerlate alternating with tribasic copper 6 Zerlate 7 No. 341 8 Fermate alternating with tribasic copper 9 Puratized 10 Fermate 11 Untreated 12 Omilite	
1946 Lenawee Co.		1 Bordeaux 2 Bordeaux alternating with Fermate 3 Tribasic copper alternating with Fermate 4 Zerlate 5 Fermate 6 Untreated	1 Zerlate 2 Fermate 3 Tribasic Copper alternating with Fermate 4 Bordeaux alternating with Fermate 5 Bordeaux 6 Untreated
1947 East Lansing	1 Phygon 2 Copper zinc chromate 3 Parzate 4 Untreated 5 Dithane Z78 6 Tribasic copper 7 Cuprocide 8 Bordeaux 9 Zerlate alternating with tribasic copper 10 Bioquin 1 11 Zerlate	1 Bordeaux 2 Cuprocide 3 Tribasic copper 4 Phygon 5 Copper zinc chromate 6 {Zerlate* Parzate Dithane Z78 7 Bioquin 8 Zerlate alternating with tribasic copper 9 Untreated	

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DISCUSSION

As has been frequently observed, there was no relationship between yield and disease control. Sometimes the best fungicides have a deleterious effect on yield that are only overcome in seasons when diseases are very prevalent and severe. Bordeaux mixture, Cuprocide, and Tribasic copper sulfate seem to hold the lead on the basis of blight control with copper zinc chromate, Dithane 14, and Phygon following closely.

Omilite appears to have no fungicidal value in controlling these tomato diseases, and failed to enhance the effectiveness of tribasic

copper when used with it as a sticker. Puratized was not satisfactory. The wax emulsion was not expected to have any value as a fungicide but was tried in the belief that it might reduce the percentage of culls due to blossom end rot which it did; however, any value it had in this respect was more than offset by its depressing effect on yield.

Zerlate and Fermate control anthracnose, the former being superior in that it will also afford some protection against Alternaria blight. However, neither will control late blight. The alternating schedule with Zerlate and a copper is superior to Zerlate alone against blight.

Dithane 14, a liquid that is mixed with zinc sulfate and lime to make the spray, was a somewhat more effective fungicide than Dithane Z78 or Parzate which are essentially the same chemical in a dry, powdered form. The two last named have the advantage that they may be mixed with diluents and applied as dust treatments.

No. 341 showed some promise in 1946 but was withdrawn by the manufacturer owing to production problems. Bioquin 1 was disappointing in these tests but has been reported elsewhere to be effective against anthracnose.

CONCLUSIONS

It is seldom advisable to make recommendations about a fungicide on the basis of a single season test. However similar tests have also been conducted in other states where a variety of weather and disease conditions prevailed. On the basis of these cooperative tests, some conclusions may be drawn.

Phygon, the Dithanes and Parzate offer dependable control of the blight diseases but are somewhat more expensive than the insoluble coppers or bordeaux mixture. Phygon has been reported to be slightly toxic to foliage and to cause a spotting of tomato fruit. These effects were not observed in Michigan tests.

Fermate, Zerlate and Bioquin 1 will control tomato anthracnose effectively. Fermate has little value in controlling the blight diseases, while Zerlate is partially effective against early blight but not against late blight. Bioquin 1 seems to offer control of anthracnose and blight as well. However, it is not so effective in the latter capacity as the insoluble coppers or bordeaux, and is considerably more expensive.

USE OF THE AMMONIUM SALT OF TRICHLOROACETATE, THE SODIUM SALT OF TRICHLOROACETATE, AMMONIUM THIOCYANATE, AND HERBICIDE "PB", IN THE ERADICATION OF GRASSES, AND THE EFFECT OF THESE CHEMICALS ON STRAWBERRY AND RASPBERRY PLANTS[1]

By R. F. CARLSON and J. E. MOULTON[2]
SECTION OF HORTICULTURE

GRASSES, especially quack grass (*Agropyron repens* L.), often are a serious problem in cultivated crops. It has been reported (2, 7) that IPC (isopropylphenylcarbamate) is effective in controlling quack grass when applied to the rhizomes. Since this compound is comparatively insoluble and has no appreciable effect when applied to the top of grasses, several water-soluble compounds were tested in the greenhouse in an attempt to find a herbicide effective when applied to the foliage.

MATERIALS AND METHODS

The compounds tested were the ammonium salt of trichloroacetate, the sodium salt of trichloroacetate, ammonium thiocyanate, and herbicide "PB". The grasses used in these tests were quack grass (*Agropyron repens* L.) and Kentucky bluegrass (*Poa pratensis* L.) which often become troublesome weeds in small fruit plantations. The grasses were started in flats (19 x 14 x 3½ inches) in the greenhouse by transferring rhizomes of quack grass and clusters of bluegrass sod from the field. Applications of the chemicals were made with a knapsack sprayer delivering a cone-type spray or with a sprinkler with small holes in the rose. Applications were made at various stages of growth of the grass from planting time to one foot tall.

[1]This work was made possible through a grant from The Pittsburgh Plate Glass Company, Pittsburgh, Pennsylvania.

[2]The authors wish to acknowledge the aid of E. I. du Pont de Nemours & Company, Inc., Wilmington 98, Delaware, in supplying the ammonium salt of trichloroacetate; the B. F. Goodrich Chemical Company, Cleveland 15, Ohio, for supplying the herbicide "PB"; and The Dow Chemical Company, Midland, Michigan, for furnishing the sodium salt of trichloroacetate.

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RESULTS

The Ammonium Salt of Trichloroacetate

Preliminary tests with the ammonium salt of trichloroacetate (hereafter in this paper trichloroacetate will be referred to as TCA) as a herbicide were made by E. I. du Pont de Nemours & Company, Inc., in 1947 (1). These tests suggested further investigations. Later reports at the annual meeting of the North Central Weed Control Conference indicated that the ammonium salt of TCA is effective in the control of Johnson, Bermuda, and quack grass (3, 5, 6, and 8).

The equivalent of one gram of the actual acetate was prepared from a 20-percent stock solution and applied to each flat with a sprinkling can at each of the following stages of growth: a) At the time of planting, b) just as the shoots were emerging, and c) when the plants were 5 and 12 inches tall. Five hundred ml. of the solution were applied to each flat. This actually amounted to a soil application in the first two flats and a combination soil and foliage application in the other two flats. A fifth flat was left untreated as a check.

After 10 days there were no new shoots from the rhizomes in the flat treated immediately following planting. The grass treated when emerging was stunted and turned a dark green color. After 10 days the leaves turned brown and died. The two flats treated when the plants were 5 and 12 inches tall showed similar stunting and dark green color and only a few new shoots appeared, but the stunted plants finally withered and died (Table 1 and Fig. 1). That the re-

TABLE 1—*The response of quack grass to the ammonium salt of TCA. One gram of the salt in 500 ml. of water was applied to each flat at different stages of plant growth*

Stage of growth when treated	Date treated	Number of green grass shoots at dates indicated					Remarks
		Dec. 6	Dec. 20	Jan. 4	Jan. 18	Feb. 2	Mar. 2
At planting	Nov. 18	0	0	0	0	0	No growth
Emerging	Nov. 24	7	4	0	0	0	No regrowth
5 inches	Nov. 30	97	89	64	52	43	Dwarf—Dark green
12 inches	Dec. 6	89	87	57	52	52	Dwarf—Dark green
Control		92	103	123	137	178	Lush growth

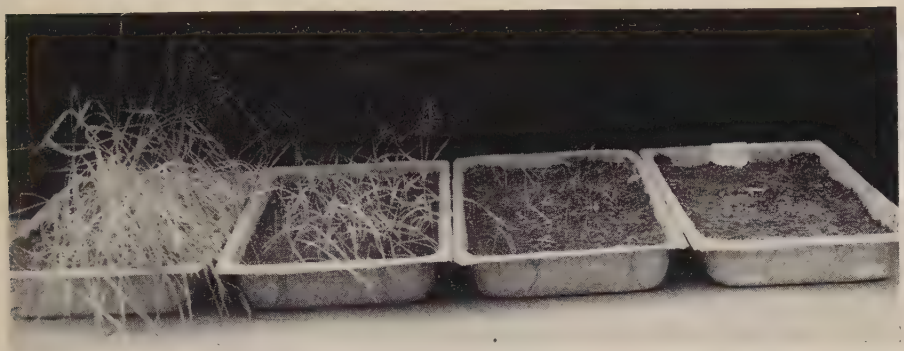

Fig. 1. Quack grass, untreated flat at left. The other three flats, left to right, each were treated with one gram of the sodium salt of TCA in 500 ml. of water at each of the following stages of growth: when 12 inches tall, when 5 inches tall, and when emerging.

sponse is systemic was indicated by the slow death of the plants and the absence of burning on the leaves. The younger the grass, the greater was the response to the treatment.

The Sodium Salt of TCA

The sodium salt of TCA, a water-soluble powder, was applied to other flats containing quack grass in a similar manner, at the same time and at the same rate (1 gram per flat) as the ammonium salt of TCA treatments described above. This was done to compare the relative effectiveness of the two formulations. There was no noticeable difference in their effect on quack grass, both being equally effective in slowly retarding the growth. That is, the grass after 6 to 8 days turned dark green, became stunted, then chlorotic, and only a small percentage recovered.

Kentucky bluegrass responded in a similar way to these chemicals.

Use of a Wetting Agent with the Ammonium Salt of TCA and the Sodium Salt of TCA

Since grasses do not adsorb aqueous solutions readily, Dreft was used at the rate of 0.5 gram per 500 ml. of solution to get better wetting of the foliage. The materials, the ammonium salt of TCA and the sodium salt of TCA, were each used at the rate of 3, 4, and 5 grams per flat, or 120, 160, and 200 pounds per acre respectively, in order to compare their effectiveness and the approximate rates

per acre required to kill the grass. The quack grass at the time of application was from 12 to 15 inches tall and well established in the flats. Each flat averaged 150 "crowns" per flat, a "crown" being considered a focus at the surface level of the ground where one to several "grass-shoots" originated. A knapsack sprayer was used to apply 500 ml. of the solution per flat. This volume was enough to wet thoroughly the foliage of the grass in the individual flats, but not sufficient to moisten the soil.

The results are shown in Table 2. As was the case in previous tests, the effect of these materials was gradual and it is doubtful that the wetting agent increased the effectiveness of the compounds. Again, the two formulations of TCA were equally effective as herbicides for quack grass.

Examinations of the rhizomes and roots three months after treatment showed that the underground parts of quack grass had been injured severely by the various chemicals (Fig. 2). As indicated in Table 2, the different concentrations of the materials produced vary-

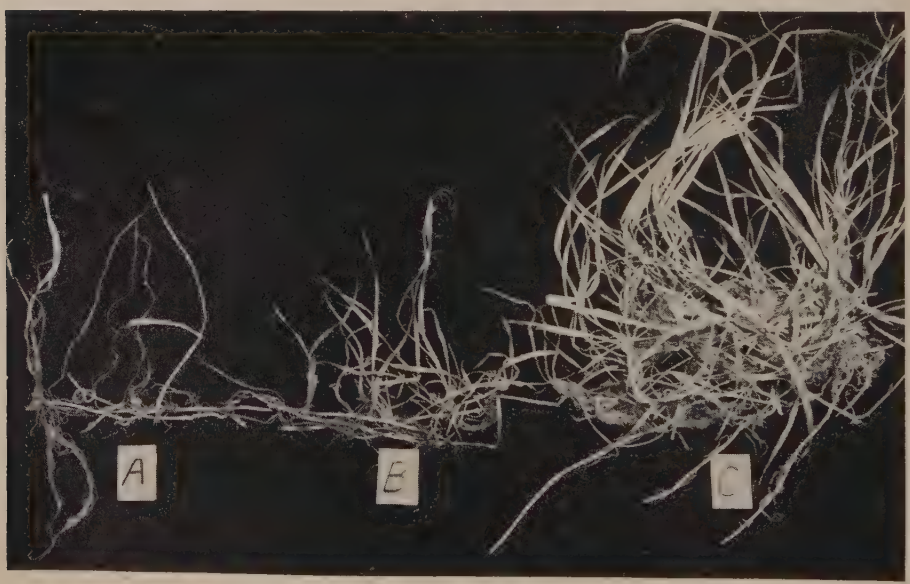

Fig. 2. Response of quack grass to foliage applications with the sodium salt of TCA. A. At the rate of 5 grams per flat. B. At the rate of 3 grams per flat. C. Control. The foliage, rhizomes and roots at the higher concentrations (A) are dead, while some "dwarf" growth appeared at the lower concentration (B). Note new growth of rhizomes in control (C).

TABLE 2—*Number of quack grass crowns alive per flat at 15-day intervals following individual foliage applications of the ammonium salt of TCA, the sodium salt of TCA, and ammonium thiocyanate at three concentrations. Dreft was used as a wetting agent at the rate of 0.5 gram per 500 ml. of the solution per flat*

Grams per flat	Approximate pounds per acre	Number of crowns alive at indicated days following treatment				Condition of rhizomes 2 months after treatment
		15	30	45	60	
Ammonium salt of TCA						
3	120	144	67	60	60	20% alive. Some new rhizomes
4	160	139	53	46	15	4% alive. No new rhizomes
5	200	153	23	15	0	Dead
Control	0	142	147	152	155	Normal
Sodium salt of TCA						
3	120	150	75	43	10	Few old rhizomes alive. No new rhizomes
4	160	157	60	38	5	2% alive. No new rhizomes
5	200	143	43	15	2	Dead
Control	0	147	153	156	156	Normal
Ammonium thiocyanate						
3	120	151	113	114	112	80% alive. Many new rhizomes
4	160	143	102	108	108	30% alive. Few new rhizomes
5	200	128	53	32	12	3% alive. Some new rhizomes
Control	0	148	151	156	157	Normal

ing results. At the higher concentration there was little development of new buds and shoots, while at the lower concentration there was some weak growth.

Ammonium Thiocyanate[1]

It has been briefly reported (4) that ammonium thiocyanate (ATC) and 2,4-D mixed with the soil will control quack grass and Chrysanthemum weed (*Artemisia vulgaris* L.). In order to find out what effect ATC had on top growth of quack grass and to compare it with the ammonium salt of TCA and the sodium salt of TCA, several applications to flats of quack grass at various concentrations (3, 4, and 5 grams per flat) were made. The material was applied when the grass was 3 and 10 inches tall. The effect of this material was more pronounced when applied to the young plants than it was on the taller and better established quack grass. Table 2 shows that

[1]This material was supplied by Prof. A. M. S. Pridham of Cornell University who has also been testing this compound and suggested that it be included in these tests.

ammonium thiocyanate at the lower concentrations was not so effective as the ammonium salt of TCA and the sodium salt of TCA in reducing growth of the grasses.

Herbicide "PB"

Herbicide "PB" was suggested as a possible grass killer by the B. F. Goodrich Chemical Company. It was applied to flats of quack grass 10 inches tall in 10-, 20-, and 30-percent aqueous solutions. A number of broad-leaved weeds were growing in with the quack grass at the time of application. Four weeks after being sprayed the quack grass appeared normal, while all the broad-leaved weeds were dead. The herbicide "PB" is selective in its action, as these tests indicate, and may have value as a selective herbicide.

Response of Raspberry Plants to the Ammonium Salt of TCA

Five raspberry plants each of three varieties, Taylor, Latham, and Cuthbert, were sprayed with the ammonium salt of TCA when dormant and when in full foliage. The same number of plants of each variety were left untreated. The plants were transplanted in October from the field to the greenhouse and set in 8-inch pots and kept at 55° F. for 3 months, after which they were placed in a 75° F. room for forcing. The dormant applications were made November 28 in aqueous solution at the rate of 1,500 p.p.m. The foliage applications at the rate of 1,000 p.p.m. were made after the leaves had developed and new shoots had formed. In each case the plants were covered with solution, but not enough of the spray was applied to moisten the soil surface of the pot.

The first few leaves which appeared from lateral buds on the plants that received the dormant applications were dark green and some formative effects were observed. That is, the leaves did not grow to full size and appeared rugose. However, later leaves showed no such effects. Also, the new shoots arising from the roots were normal. This indicated a delaying action of the dormant application on the plants, but the effects were outgrown after 4 weeks and were not serious enough to retard the general growth of the plants.

The plants sprayed when in leaf showed symptoms similar to mineral deficiencies; that is, the margins of the leaves, and also areas between the veins were chlorotic 5 to 6 days following treatment. Four weeks later the margins of the leaves had turned brown while

the chlorotic regions between the veins remained unchanged or turned a darker green color. The effects produced by the ammonium salt of TCA at 1,000 p.p.m. sprayed on the foliage were not serious enough to appreciably check the growth of the plants. In both tests all varieties showed equal response to the treatments, while the check plants appeared normal.

Response of Strawberry Plants to the Ammonium Salt of TCA and the Sodium Salt of TCA

Strawberry plants of two varieties, Premier and Robinson, were grown in flats together with quack grass and Kentucky bluegrass. After the plants were well established and the grass was about 10 inches tall, applications of the ammonium salt of TCA and the sodium salt of TCA at concentrations of 500, 1,000, and 1,500 p.p.m. were made. Sufficient amount of the solution to wet the foliage was applied. This is approximately equivalent to 20, 40, and 60 pounds of the chemical per acre respectively. The strawberry plants were killed at all concentrations and the grasses were also severely injured, especially at the higher concentrations. The untreated flats of grasses and strawberry plants were normal.

Residual Effect in Soil Following Treatment with the Ammonium Salt of TCA

The residual effect of the ammonium salt of TCA was tested by saturating one flat of soil with one liter of a 1,000 p.p.m. solution and a second flat with one liter of a 2,000 p.p.m. solution. Red kidney beans were planted at weekly intervals in these flats. The soil was watered as needed. The beans from the first, second, and third plantings germinated and produced the first true leaves after which the plants gradually withered and died. The beans from the fourth and fifth plantings showed some injury along the margins of the first true leaves, but the plants recovered sufficiently to continue to grow. The beans from the sixth planting were apparently normal. This indicates that in moist soil the chemical will remain toxic to bean plants 40 to 50 days following soil applications at the above-mentioned rates.

SUMMARY AND CONCLUSIONS

1. The ammonium salt of TCA and the sodium salt of TCA were found equally effective in controlling quack grass and Kentucky bluegrass as tested under greenhouse conditions. Approximately 150 to

200 pounds per acre was required for a complete kill of the well established grass. The lower rates, 40 to 80 pounds per acre, controlled the young grass growth and retarded the taller and older grasses. The wetting agent, Dreft, did not materially increase the effectiveness of these compounds.

2. The herbicidal action of the ammonium salt of TCA and the sodium salt of TCA was slow on the grasses tested, suggesting that the materials were absorbed by the foliage and translocated to the underground parts (rhizomes and roots). The leaves gradually changed in color from a light to a dark green and after 4 weeks became chlorotic and withered.

3. Ammonium thiocyanate was not as effective as the ammonium salt of TCA and the sodium salt of TCA on grasses when used at equal concentrations.

4. Herbicide "PB" proved to be effective on broad-leaved weeds and did not injure the grasses.

5. Raspberry and strawberry plants were tested for resistance to the ammonium salt of TCA and the sodium salt of TCA. The strawberry plants were killed when herbicidal concentrations were used. Formative effects were produced on raspberry plants after dormant applications and deficiency symptoms after foliage sprays. Both effects were outgrown.

6. The ammonium salt of TCA in moist soil remained toxic to red kidney beans 40 to 50 days following soil applications.

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A COLORIMETRIC TEST FOR ESTIMATING THE PERCENTAGE MOISTURE OR THE STORAGE QUALITY OF FARM PRODUCTS OR OTHER DRY MATERIALS

By S. T. DEXTER
SECTION OF FARM CROPS

IN A PREVIOUS paper[1] a test was described in which the keeping quality of either hay or grain could be quickly estimated. This test was dependent upon the fact that certain chemicals become moist and and sticky when they are exposed for a brief time at a relative humidity above a critical figure.

To avoid molding of the ordinary farm crops under storage conditions in Michigan, the relative humidity of the air surrounding them in the bin or mow should not long remain higher than 80 to 85 percent. For storage in large quantities, or in a very tight storage, a lower initial figure would be necessary. In ordinary farm storage, there is some movement of air, with consequent lowered relative humidity and appreciable drying out in the course of the first few days, so that molding is avoided. To the contrary, in a tight storage with the air remaining at 80 to 85 percent relative humidity, molding of hay or grain will occur within a week or two at summer temperatures.

The test as described was designed to indicate whether grain or hay could safely be put in ordinary storage. This was done by simply shaking in a tight container a sample of grain with ammonium chloride, and observing whether the chemical became sticky or moist. While, with experience, it gives considerable indication of the degree of excess dampness, it gives little indication of extreme dryness. For those reasons, and for greater ease of reading over a much wider range, a further test has been developed, in which color changes indicate the degree of dampness of the product.

Two dry chemical mixtures have been devised, to be shaken up

[1] A Method of Estimating Whether Hay or Grain Will Keep in Storage. Mich. Exp. Sta. Quart. Bull. 30 (2) (Nov. 1948): 150-157.

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with the samples. With one chemical, a gradual color change from almost white to a deep red indicates a range of moisture content from 7 to 12 percent in oats or wheat. With the other mixture, a change from almost white to a deep blue indicates a moisture content range from 12 to 17 percent. (See color plate insert in center of this bulletin.) It should be recognized that these numerical values for percentage are not applicable to all materials. Thus, a pale blue color (meaning "suitable for ordinary storage") would be produced at entirely different moisture contents in sugar, starch, hay, flaxseed, etc.

OTHER USES

Since these tests cover a wide range, they have many other uses than for testing grain and hay. For example, small pieces of paper stored at various relative humidities will soon reach different equilibrium moisture contents. If any one of these pieces of paper is placed in a closed container and shaken up with a small amount of the indicator chemical, a color will be formed that is characteristic of the particular relative humidity in question. Or if a piece of wood is stored at any given relative humidity, it will reach a certain moisture content. If a few scraps of the wood are similarly shaken up with the chemical, a color will be formed that indicates the moisture content of the wood—or more important, the relative humidity at which it is in equilibrium. Such a test would, for example, reveal whether lumber was suitable for installing as flooring.

OTHER METHODS OF USE

In the case of ground mill feeds, flour, etc., the material being tested may readily contaminate the testing chemical unduly, or dilute the color. In such cases, it has been found both easy and rapid to place the chemical in a tissue-paper envelope, and to insert this in the container with the material to be tested. Within a very few minutes, the chemical reaches its characteristic color for a certain moisture content.

CALIBRATION OF THE TEST

Since the test can be used on such a variety of materials, it has seemed pointless—in fact, impossible—to calibrate it for all possible uses. If the "blue reagent" is used for testing filler tobacco, a certain shade of blue would indicate that the tobacco was at the proper mois-

ture content. If the "red reagent" is used on flooring, a light pink would indicate a suitable moisture content. When tested with the "blue reagent," wheat for storage in very large quantities should give a very light blue, but with the "red reagent" should give a dark red. For ordinary farm storage, a somewhat darker blue would be the proper condition. Hay suitable for baling or chopping into an unventilated mow should give a rather light blue; but for long hay, a darker blue would be permissible. In all these cases, as previously pointed out, the local conditions are of importance, and the chemical should be quickly calibrated on the job for the particular temperature and humidity condition in question. In general, testing of storage characteristics should be done at or near the temperature at which storage is to take place. In any case, the range of the test is so great that the moisture conditions of most "dry" materials will fall within it; if not, additional testing chemicals can be devised.

USE OF THE TEST

A small sample of the material to be tested is placed in a glass container. In general, filling about one-third full allows for convenient shaking. A small amount—the precise amount is of no consequence—of the testing chemical is added, and the mixture shaken thoroughly. Depending upon the readiness of evaporation from the surface of the sample, the approximate maximum color will be developed in from 50 to 200 shakes. With materials providing very free evaporation—such as tissue paper or sugar beet pulp—the color reaction may be even more rapid.

Many samples have been stored with the chemical over periods of several weeks, with no notable change in the color beyond that produced in the first minute or two.

In many cases, with experience, there is no object in shaking until the maximum color develops. For example, in testing oats or wheat, if after 10 shakes—5 or 10 seconds—the color of the "blue reagent" is decidedly blue, the sample obviously is too wet to store.

PRINCIPLES OR THEORY OF THE TEST

Considerable adsorption of water takes place upon the crystal faces of a dry chemical before the water concentration becomes high enough to cause actual solution or observable wetting. This adsorption, or incipient solution, furnishes sufficient moisture, however, to initiate

various chemical (or physical) actions of other chemical systems, that, in this case, produce brilliant colors. The choice of chemicals that will indicate the moisture of the air is, of course, almost limitless. So also, there are a great number of color reactions that have been tried with more or less success. In the tests in question, it seemed desirable to use an indicator chemical that would give a somewhat sharp break in color at about 14-percent moisture in oats or wheat. This has been done. To the contrary, there would be no difficulty in providing a testing mixture that would show a strong break in color at, say, 12-percent moisture. Thus, as shown in the color plate, a chemical mixture has been prepared which changes from almost white to a deep blue in the range shown. In practice, it may be used to still higher percentages.

It seemed desirable to extend the range into drier materials, and in that range to provide a different color, to avoid any possible confusion. Another indicator chemical and a different color reaction was therefore used, as shown in the color plate.

CHEMICALS INVOLVED

In the mixture that gives a blue coloration, common table salt (Crystal Diamond Salt, not iodized) is used to adsorb the water. It does this very strongly, becoming wet and sticky, if the moisture content of the oats or wheat exceeds 15 percent. Even though it appears "dry" at 13 percent, a slight blue color develops. The chemicals that react to give the blue color are ferric ammonium sulfate (anhydrous) and potassium ferrocyanide. These chemicals are almost colorless, while the ferric ferrocyanide that is formed is an intense blue.

In the mixture that gives a red coloration, potassium thiocyanate is used to adsorb water. It does this much more readily than does common salt and becomes wet and sticky if the moisture content of the grain is above 11 percent. Even though it appears dry at 9-percent moisture, for example, there is nevertheless some moisture adsorbed, which leads to the reaction with ferric sulfate, giving the red color, ferric thiocyanate. This color is distributed over the surface of a filler (common salt), which has no part in the reaction.

It is evident that the chemicals going into the color reaction must not be as sensitive to moisture as the adsorbing chemical. Not so evident is the fact that none of the chemicals may interfere with the color reaction, nor may any of them chemically react with water, for

this would make necessary a sample of fixed size. Furthermore, no part of the chemical mixture may be porous or have great adsorbing capacity for water — as do wheat, oats, paper, etc., etc. — but rather, all must have solid crystal faces, which require only the most minute quantities of water for their saturation.

MANUFACTURE

Although it is theoretically possible for a private individual to manufacture these products at very slight expense, in actual practice it would be comparable to manufacturing one's own ink. When purchasing a bottle of ink, one is assured of a good standard product that "works". Consequently, patent applications assigned to Michigan State College have been made on this product, and it is anticipated that it will soon be on the market in a convenient and reliable form.

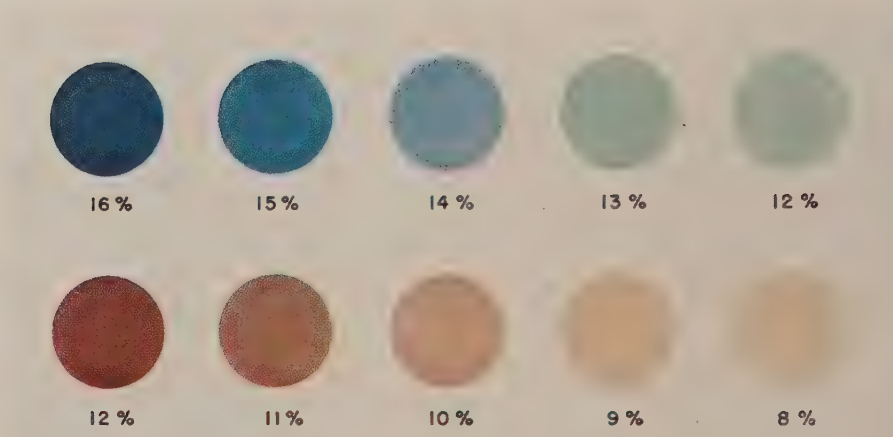

Plate 1. The colors are those resulting in the two testing mixtures when shaken up with wheat at the moisture percentages indicated.

Plate 2. Wheat at 15 and 13 percent moisture content when shaken up with the blue testing mixture resulted in the colors shown.

THE CHEMICAL CONTROL OF CERTAIN FOREST SHRUBS: A PROGRESS REPORT

By MAURICE W. DAY
DUNBAR FOREST EXPERIMENT STATION

MANY THOUSANDS of acres of potentially productive forest land in the Lake States are covered with a stand of shrubs, making it difficult to establish stands of desirable tree species either by natural or by artificial methods. One of the major silvicultural problems of the region is the establishment of stands of timber upon these extensive brush areas and the securing of natural reproduction in understocked stands having a shrub under-story. More knowledge is needed regarding these shrub species and of the limitations and possibilities of the various methods of controlling them.

The problem of controlling woody plants is not confined however to the field of silviculture. Large sums are spent yearly in attempting to eradicate woody plants on right-of-ways along highways, railroads, drainage ditches and power lines. Farmers and ranchers are also often concerned with the eradication of woody plants from permanent pastures where their presence reduces the available forage.

The object of the work being described was primarily that of testing some new substances and methods that might prove of value in shrub control. While shrub control methods fall into three classes, namely chemical, mechanical and silvicultural, only the work dealing with chemical control will be considered here.

Ammonium sulphamate was the first substance tested on some of the shrubs. Several preparations of 2,4-D (2,4-Dichlorophenoxyacetic acid) were used. Two preparations containing DNOSBP (dinitro ortho secondary butyl phenol) were tested also. These preparations can be briefly described as follows:

1. Weedone, a product of the American Chemical Paint Co. containing the ethyl ester of 2,4-D. It was used in a water solution of 1,250 p.p.m.

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2. Dow A510 (2,4-Dow powder), a product of the Dow Chemical Co. containing the sodium salt of 2,4-D, and used in water solution of 1,000 p.p.m.

3. Dow G414, an experimental product of the Dow Chemical Co. containing 14-percent dinitro ortho secondary butyl phenol (designated DNOSBP for convenience). Used as an oil solution containing .05 pound of the toxicant per gallon.

4. Dow G512, containing 2,4-D in the form of the methyl ester plus one-half the concentration of DNOSBP found in G414. This was used in an oil solution containing .025 pound of toxicant per gallon and 1,665 p.p.m. of 2,4-D.

5. Dow G536, containing the methyl ester of 2,4-D. This was used in an oil solution at 1,000 p.p.m. and 1,665 p.p.m.

6. Dow G652, containing the methyl ester of 2,4-D in more concentrated form. Used in both water and kerosene solution at from 1,000 to 3,000 p.p.m.

7. Esteron 44, a Dow Chemical Co. product containing the isopropyl ester of 2,4-D. It was used in several different formulations.

The materials listed above were applied in several different manners. The foliage sprays were applied to the leaf surface of the shrubs with a knapsack garden sprayer. When used as a stem spray, the spray was applied from the ground line to a height of about 4 feet on all sides of the stem. The cut stump spray was applied in the same manner to freshly cut stumps up to 5 inches in diameter. Those materials listed as being placed in holes in the stem were poured into holes about ½ inch in diameter and extending about 1 inch into the stem. These holes were made with a special axe devised for use with sodium arsenite. One other method of application was used with the dry powder of A510, which was placed in slits in the bark cut so as to expose the cambium.

RESULTS

The results of the trials of the various herbicides have been summarized in Table 1. It is apparent that many inconsistent results have been obtained which indicate inadequate and incomplete experimentation; however, it is hoped that the results will provide some guides for further work along these lines.

TABLE 1—*Summary of results of chemical treatments*

Species	Formulation	Treatment	Reaction
Alder (*Alnus incana*)	methyl ester 1000 ppm	foliage spray	I
	methyl ester 1500 ppm	foliage spray	I–II
	ethyl ester 1250 ppm	foliage spray	I–II
	sodium salt 1000 ppm	foliage spray	I–IV
	methyl ester 1665 ppm. in kerosene	foliage spray	I
	DNOSBP .05 lb. per gal. in kerosene	foliage and stem spray	II–III
	methyl ester 1665 ppm. plus DNOSBP .025 lb. per gal. in kerosene.	foliage and stem spray	II
	sodium salt 1000 ppm. plus $NaClO_3$	foliage spray	I
	ammonium sulphamate	foliage spray	II
	methyl ester 3000 ppm. in kerosene	cut stump spray	I
	methyl ester 1665 ppm. in kerosene	cut stump spray	II
	methyl ester 1665 ppm. plus DNOSBP .025 lb. per gal. in kerosene.	cut stump spray	II
	DNOSBP .05 lb. per gal. in kerosene	cut stump spray	IV
	sodium salt 70% 2,4-D	powder placed under bark	I
Aspen (*Populus tremuloides*)	ethyl ester 1250 ppm	foliage spray	III–IV
	sodium salt 1000 ppm. plus $NaClO_3$	foliage spray	II–IV
	sodium salt 1000 ppm	foliage spray	III–IV
	methyl ester 1665 ppm. in kerosene	foliage spray	II
	ammonium sulphamate	foliage spray	II
	DNOSBP .05 lb. per gal. in kerosene	stem spray	I–II
	methyl ester 1665 ppm. in kerosene plus DNOSBP .05 lb. per gal.	stem spray	II
	methyl ester 1665 ppm. in kerosene plus DNOSBP .05 lb. per gal.	in holes in stem	III–IV
	methyl ester 1665 ppm. in kerosene	in holes in stem	II–III
	sodium salt 70% 2,4-D	placed in slits under bark	II
	ammonium sulphamate	in holes in stem	II
	methyl ester 3000 ppm. in kerosene	in holes in stem	III–IV
Aspen, big tooth (*Populus grandidentata*)	ethyl ester 1250 ppm	foliage spray	II
	ammonium sulphamate	foliage spray	II
	DNOSBP .05 lb. per gal. in kerosene	stem spray	I
Balsam poplar (*Populus Tacamahaca*)	methyl ester 1000 ppm	foliage spray	II
	ethyl ester 1250 ppm	foliage spray	I

All treatments made during the mid-season period July 1 to August 15. (1945-47).
Reaction types I, hypersensitive—II, sensitive—III, semi-tolerant—IV, tolerant.
All formulations are in water unless otherwise noted.
All formulations are of 2, 4-D unless otherwise noted.
The symbol DNOSBP refers to the toxicant dinitro ortho secondary butyl phenol.
The cut stump sprays were applied to freshly cut stumps 1 to 5 inches in diameter.

TABLE 1—*Continued*

Species	Formulation	Treatment	Reaction
Chokecherry (*Prunus virginiana*)	ethyl ester 1250 ppm	foliage spray	II–IV
	sodium salt 1000 ppm	foliage spray	IV
	methyl ester 1665 ppm. in kerosene	foliage spray	II
	isopropyl ester 1500 ppm	foliage spray	III
	isopropyl ester 2000 ppm	foliage spray	III
	isopropyl ester 4000 ppm. in fuel oil	foliage spray	I–II
	methyl ester 1000 ppm	foliage spray	II–IV
	DNOSBP .05 lb. per gal. plus methyl ester 1665 ppm. in kerosene.	stem spray	II
	ammonium sulphamate	foliage spray	III
Dogwood (*Cornus alternifolia*)	methyl ester 1000 ppm.	foliage spray	IV
Hawthorn (*Crateagus* sp.)	DNOSBP .05 lb. per gal. in kerosene	stem spray	II
	ethyl ester 1250 ppm	foliage spray	III–IV
	sodium salt 1000 ppm	foliage spray	IV
	methyl ester 1665 ppm. in kerosene	foliage spray	IV
	ammonium sulphamate	foliage spray	II
	methyl ester 4500 ppm. in fuel oil	cut stump spray	I–III
	methyl ester 1000 ppm	foliage spray	II
	ethyl ester 1250 ppm	foliage spray on fresh sprouts	II
Hazel (*Corylus cornuta*)	ammonium sulphamate	foliage spray	II
	ethyl ester 1250 ppm	foliage spray	I–II
	sodium salt 1000 ppm	foliage spray	I–III
	sodium salt plus $NaClO_2$	foliage spray	I–II
	DNOSBP .05 lb. per gal. in kerosene	foliage and stem spray	III
	DNOSBP .025 lb. per gal. plus methyl ester 1665 ppm. in kerosene.	foliage and stem spray	II
	methyl ester 1665 ppm. in kerosene	foliage spray	II
	methyl ester 3000 ppm	foliage spray	I
	methyl ester 1000 ppm	foliage spray	I
	methyl ester 4500 ppm. in kerosene	cut stump spray	I
	isopropyl ester 1500 ppm	foliage spray	I

All treatments made during the mid-season period July 1 to August 15. (1945-47).
Reaction types I, hypersensitive—II, sensitive—III, semi-tolerant—IV, tolerant.
All formulations are in water unless otherwise noted.
All formulations are of 2, 4-D unless otherwise noted.
The symbol DNOSBP refers to the toxicant dinitro ortho secondary butyl phenol.
The cut stump sprays were applied to freshly cut stumps 1 to 5 inches in diameter.

TABLE 1—*Continued*

Species	Formulation	Treatment	Reaction
Juneberry (*Amelanchier* sp.)	DNOSBP .05 lb. per gal. in kerosene...	foliage and stem spray.....	III
	ethyl ester 1250 ppm.....	foliage spray.....	III
	sodium salt 1000 ppm.....	foliage spray.....	II–III
	methyl ester 1665 ppm. in kerosene....	foliage spray.....	II
	ammonium sulphamate.....	foliage spray.....	I
Mt. maple (*Acer spicatum*)	methyl ester 1665 ppm. in kerosene....	foliage spray.....	III
	methyl ester 1000 ppm.....	foliage spray.....	III–IV
	methyl ester 3000 ppm. in kerosene....	foliage spray.....	III–IV
	ethyl ester 1250 ppm.....	foliage spray.....	IV
Pin cherry (*Prunus pensylranica*)	sodium salt 1000 ppm.....	foliage spray.....	II
	ethyl ester 1250 ppm.....	foliage spray.....	II–III
	methyl ester 1665 ppm. in kerosene....	foliage spray.....	I–III
	ammonium sulphamate.....	foliage spray.....	II
	DNOSBP .025 lb. per gal. plus 1665 ppm. methyl ester in kerosene.	stem and foliage spray.....	I
	methyl ester 4500 ppm. in kerosene....	cut stump spray.....	I–III
	methyl ester 1000 ppm.....	foliage spray.....	III
	methyl ester 3000 ppm. in fuel oil.....	foliage spray.....	III
Red maple (*Acer rubrum*)	sodium salt 1000 ppm.....	foliage spray.....	IV
	ammonium sulphamate.....	foliage spray.....	II–III
	ammonium sulphamate.....	placed in holes in stem.....	II
	DNOSBP .05 lb. per gal. in kerosene...	stem and foliage spray.....	II–IV
	DNOSBP .025 lb. per gal. plus 1665 ppm. methyl ester in kerosene.	stem and foliage spray.....	III
	DNOSBP .025 lb. per gal. plus 1665 ppm. methyl ester in kerosene.	cut stump spray.....	II
	methyl ester 4500 ppm. in kerosene....	cut stump spray.....	I–II
	ethyl ester 1250 ppm.....	foliage spray.....	IV
	methyl ester 1665 ppm. in kerosene....	foliage spray.....	IV
	methyl ester 3000 ppm. in kerosene....	cut stump spray.....	II–III
	sodium salt 70% 2,4-D.....	powder placed in slits under bark	III–IV
	isopropyl ester 4000 ppm.....	foliage spray.....	III
	isopropyl ester 1500 ppm.....	foliage spray.....	III–IV
	isopropyl ester 4000 ppm. in fuel oil....	foliage spray.....	III
	methyl ester 1000 ppm.....	foliage spray.....	IV

All treatments made during the mid-season period July 1 to August 15. (1945-47).
Reaction types I, hypersensitive—II, sensitive—III, semi-tolerant—IV, tolerant.
All formulations are in water unless otherwise noted.
All formulations are of 2, 4-D unless otherwise noted.
The symbol DNOSBP refers to the toxicant dinitro ortho secondary butyl phenol.
The cut stump sprays were applied to freshly cut stumps 1 to 5 inches in diameter.

TABLE 1—*Concluded*

Species	Formulation	Treatment	Reaction
Willow (*Salix* sp.)	sodium salt 1000 ppm	foliage spray	I–III
	ethyl ester 1250 ppm	foliage spray	I
	methyl ester 1665 ppm. in kerosene	foliage spray	I
	methyl ester 1000 ppm	foliage spray	II–III
	methyl ester 3000 ppm. in fuel oil	cut stump spray	IV
	DNOSBP .05 lb. per gal. in kerosene	stem and foliage spray	III
	ammonium sulphamate	foliage spray	I–II
Withe-rod (*Viburnum cassinoides*)	ethyl ester 1250 ppm	foliage spray	III
	methyl ester 1665 ppm. in kerosene	foliage spray	III
	sodium salt 1000 ppm.	foliage spray	III
	DNOSBP .025 lb. per gal. plus 1665 ppm. methyl ester in kerosene.	stem and foliage spray	II–III
	DNOSBP .05 lb. per gal. in kerosene	stem and foliage spray	II–III

All treatments made during the mid-season period July 1 to August 15. (1945-47).
Reaction types I, hypersensitive—II, sensitive—III, semi-tolerant—IV, tolerant.
All formulations are in water unless otherwise noted.
All formulations are of 2, 4-D unless otherwise noted.
The symbol DNOSBP refers to the toxicant dinitro ortho secondary butyl phenol.
The cut stump sprays were applied to freshly cut stumps 1 to 5 inches in diameter.

The results with ammonium sulphamate were generally good. The effect of this treatment on all species is evident within a few days, the death of the leaves being followed by a drying out and death of the finer twigs. The amount of stem killed and the subsequent re-sprouting varies with the species and with other factors, some of which were not determined. Of the species tested, the hazel was the most susceptible to the treatment and chokecherry was probably the most resistant although it was usually killed to the ground. Unless the spraying was done late in the season all species except hazel usually re-sprouted the same season. Hazel re-sprouted the following year but with greatly reduced vigor and even at the end of the second season following treatment, the sprouting was only 30 percent or less of that obtained by cutting.

The ammate spray kills only leaves that it strikes, and dense clumps sometimes permit the inside leaves to escape the spray and only a partial kill results. It was noted that the effect of this spray was not as lethal to certain conifers as to the shrubs. This selective action resulted in the release of desirable conifers in a number of the clumps treated.

The results obtained with the various 2,4-D formulations are shown in the table. When consistent results were not obtained the range of results is given. In determining results, the amount of sprouting occurring the following year after treatment was considered, except for the 1947 treatments which are based on examinations of the roots. It should also be noted that the results are based upon only one application of the spray material. Considerable difference in the results with 2,4-D exist between the species and the formulations. Hazel was found to be one of the most sensitive species tested while the maples were the most resistant.

In most cases the sodium salt solutions were not as effective as the esters, but in several cases they gave good results especially when sodium chlorate had been added to the spray solution. The dry powder proved very effective on alder and aspen when placed under the bark.

The esters of 2,4-D seemed to give comparable results in most cases. Increased concentrations did not seem to be especially desirable except in the case of the cut stump sprays which in the case of red maple was most effective at a concentration of 4,500 p.p.m.

The placing of 2,4-D solutions in holes in the stems of aspen did not produce any marked results.

The phenol sprays resulted in the death of all leaves or needles struck by the spray. While the shrubs were apparently quickly killed they also sprouted quickly again in most cases. When the spray was used on the stem it was found that in some cases the cambium layer was killed by penetration of the toxic material through the bark. Species, age of stem and thickness of bark influenced this action. The aspens, pin cherry and mountain maple were most susceptible to stem sprays, while red maple, juneberry and hazel were more resistant. The results with aspen have been reported elsewhere (1).

DISCUSSION OF RESULTS

A consideration of the results obtained in the experimental work with chemical control methods indicates that a number of definite possibilities exists. Several of the species are responsive to the substances used, and with the development of better methods of application, the others may also be controlled in this manner.

We have noted that all of the species being considered sprout freely, and that cutting, therefore, does not usually constitute con-

trol. Likewise, the killing of the top with a chemical accomplished no more than cutting it. Shrubs can only be killed by destroying the tissues that give rise to the sprouts. Thus in estimating the value of a chemical for the control of shrubs, one must give primary consideration to the extent of re-growth.

The work with ammonium sulphamate indicated definite possibilities with respect to hazel. While sprouting occurred it was delayed and weak, and even at the end of 3 years, was not vigorous. The other species sprouted more abundantly and with greater vigor, indicating less advantage for the method. It was noted, too, that ammonium sulphamate had a more lasting effect than the contact sprays.

The use of 2,4-D materials seems to offer the greatest possibilities. The use of 2,4-D compounds for weed control is very recent and only a few authors have considered the woody species. Hamner and Tukey (2, 3) have reported the results of work with woody species. Among the species susceptible to 2,4-D were two of the species being treated here, chokecherry and willow.

Several factors apparently influence the reaction of a plant to 2,4-D. Many variations in the results of the experiments are due to the effect of influences which are not completely understood as yet. Differences in effect were noted which were apparently due to weather conditions, particularly temperature. Higher temperatures resulted in a speeding-up of the reaction and an increase in the severity of the reaction. Marth and Davis (4), in their work with certain herbaceous plants, found higher temperatures resulted in quicker killing while lower temperatures slowed up the action. Shrubs growing on dry, sandy soils also seemed to react more quickly to 2,4-D than those on moist, heavier soils. One cause for this difference may be that such sites having a heavier vegetative cover are cooler, and the shrubs are more likely to be shaded during part of the day.

No consistent difference was noted in those treatments which were followed by rain and those that were not. It may be that some of the poor results obtained with the water-soluble salt solutions should have been assigned to this cause.

The effectiveness of 2,4-D depends upon its conduction throughout the plant, the responses induced and the destruction of certain tissues. Inasmuch as the best results were obtained during July, after the most active growth period, but during the period of highest tem-

perature and greatest transpiration rate, it would seem that the effectiveness of the spray is associated with the existence of a water deficit in the plant and a consequent rapid transport of the chemical in the xylem elements. The greater effectiveness of 2,4-D on dry sites than on moist sites, as previously mentioned, is further evidence in this direction.

Hazel and willow were the only species showing evidence of carrying some 2,4-D effects over into the year following treatment. Sprouting was the least in those species which responded the most to 2,4-D, but there were many inconsistencies and more intensive work is needed dealing with the effects of 2,4-D upon the root tissues giving rise to sprouts.

Upon the basis of these experiments it seems that many shrubs will re-sprout following 2,4-D treatment. This sprouting will, however, be much less than that obtained with cutting, and a second treatment the next season should affect control on those species which can be controlled with 2,4-D.

The contact sprays containing DNOSBP, while resulting in an immediate killing of the leaves, did not seem to have much residual effect and the sprouting resembled that which follows cutting. When the spray was used, however, as a stem spray, those species that were susceptible proved to be much more seriously injured and in many cases were unable to re-sprout.

The spray containing 2,4-D and DNOSBP did not give superior results and, in fact, there was little evidence of any 2,4-D reaction when it was used as a leaf spray. It is assumed that this was due to the other toxicant killing the leaf tissue before the 2,4-D could be translocated.

At this time it seems that the use of a concentrated 2,4-D formulation as a cut stump spray on freshly cutover areas followed later in the season by a more dilute foliage spray will give the best control of most undesirable shrubs.

SUMMARY

Experiments with some chemical weed killers as a means of controlling several species of shrubs and trees indicated several possibilities.

Ammonium sulphamate was most effective on hazel. The other species usually sprouted strongly following treatment.

Sprays containing 2,4-D were the most promising of those tried. Even the most resistant species were susceptible to some applications. In general, the esters were more effective than the sodium salt. Concentrated solutions gave promise of preventing re-sprouting of some species when applied as fresh cut stump sprays.

The dinitro-phenolic contact sprays resulted in an immediate killing of the aerial portion of the shrubs, but sprouting was immediate and vigorous in many cases. When applied as a stem spray this substance was especially effective on aspen and pin cherry.

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APPLYING FERTILIZER THROUGH IRRIGATION WATER

By F. W. PEIKERT and R. L. COOK
SECTIONS OF AGRICULTURAL ENGINEERING AND SOIL SCIENCE

NITROGEN may well be applied through irrigation water. Most of the nitrogen fertilizers are readily soluble, and the chemistry of nitrogen in the soil is such that the idea of broadcasting the fertilizer in solution is theoretically sound. Potash fertilizers may also be applied satisfactorily through irrigation water, but it is probably desirable to apply only a small portion of the total quantity in this manner and the remainder in bands at planting time. Phosphorus is not adapted to application in water and, therefore, it follows that mixed commercial fertilizers containing phosphorus should not be applied in this manner.

It is the object of this article to show why the fertilizer nutrients vary in their adaptability to applications through irrigation water and discuss rates and methods of applications.

A COMPARISON OF THE MAJOR PLANT NUTRIENTS

The three major plant nutrients, nitrogen, phosphorus and potassium vary in the way they lend themselves to application through irrigation water. The variation is largely due to differences in chemical activity in the soil and to degree of solubility of the fertilizer materials. A brief discussion of the individual nutrients, as to how they exist in the soil and in the fertilizer bag, and what happens to them in the soil shows why they are not equally adapted to this manner of application.

Nitrogen Well Adapted to Application Through Irrigation Water

Most of the nitrogen exists in the soil in the form of organic matter. Soil microorganisms decompose the organic matter and release the nitrogen as ammonia. Other organisms change the ammonia to

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nitrate nitrogen, the form in which most plants prefer their nitrogen. If the form of organic matter in the soil is highly carbonaceous in nature, as straw or corn stover, the quantity of nitrogen contained is too low for the body needs of the organisms which bring about the decomposition. At such a time the organisms collect all that is available in the soil. This includes the nitrogen which was applied as fertilizer at the time the crop was planted. Thus, nitrogen applied at planting time may be entirely used up by soil organisms before the time comes when the crop actually needs it.

This was shown to be true in greenhouse experiments[1] in which a per acre application of 900 pounds of ammonium nitrate at planting time did not furnish sufficient nitrogen to nourish sugar beets until harvest. The starvation was indicated by tests made on the green tissue. In comparison, plants which had received the same quantity of nitrogen fertilizer in three applications, one at planting time and two later, were well supplied with nitrogen throughout the season. From the weight of the crop produced and the analysis of the beets, only 50 percent of the nitrogen could be accounted for where it was all applied early, while in the other case it was possible to account for about 70 percent of the quantity applied and the tests indicated some still available to the crop at harvest time. There seems little doubt but what most of the nitrogen not accounted for was used up by soil organisms as there was no leaching from the pots.

Some of the state experiment stations have reported good response from nitrogen fertilizer applied as a side-dressing when corn was 2 to 3 feet high but very little response when the fertilizer was applied at planting time or before. It is very likely that the nitrogen which was applied early in the season was either lost through leaching or was used by soil organisms before the corn had made sufficient growth to require the supplementary application.

Carolus[2] has reported that potatoes, at the Virginia Truck Experiment Station, required only 7 pounds of nitrogen an acre during the first 7 weeks of their growth period but during the next 5 weeks the crop used 53 pounds an acre. The logical time then to apply nitrogen for such a crop is during that period of rapid growth when the need for nitrogen is great. Irrigation water, of course, offers a convenient means of making such applications during midseason.

Without irrigation, midseason applications of soluble nitrogen fer-

[1]Soil Science Society of America Proceedings *11:* 298-304, 1946.
[2]American Potato Journal *14:* 141-153, 1937.

tilizer may be ineffective because the surface soil does not contain enough moisture to dissolve the nitrogen salt. Deep placement at that season is not recommended, because of the danger of injury to roots. Irrigation water therefore furnishes a good solution to this otherwise difficult problem.

Only soluble salts can be easily and efficiently applied through irrigation water. All of the three common nitrogen salts, ammonium sulfate, ammonium nitrate, and sodium nitrate are easily and completely soluble in water.

Dates as well as rates of application of nitrogen salts through irrigation water should vary with different soils and with crops. Perhaps one should always apply a small quantity of nitrogen at planting time, just in case rainfall is plentiful for a time and no irrigation is needed. Tests made on the soil and on the green plants along through the season should furnish worthwhile clues as to when nitrogen should be first placed in the irrigation water. With most crops it will be several weeks after planting, when vegetative growth becomes rapid. Forty to eighty pounds of nitrogen applied per acre during the rapid growth period should be sufficient for most crops. The smaller quantity would be contained in approximately 200 pounds of ammonium sulfate, 120 pounds of ammonium nitrate, or 240 pounds of sodium nitrate. If it is contemplated that the rapid growth period of the crop will last 6 weeks it is recommended that one-sixth of the total quantity of nitrogen be applied each week.

Potash at Planting Time and Through Irrigation Water

Potassium salts are largely soluble in water and the element does not readily form unavailable compounds in the soil, so it is easy and theoretically correct to apply potash fertilizer through irrigation water if desirable. However, there is probably little reason to recommend the method of application for this fertilizer except when additional applications are needed. Potassium does not leach readily and it is not used in large amounts by soil organisms, as is the case with nitrogen. Therefore, it is correct to apply all the potash at the time of planting or before. However, one may not be able to predict exactly the needs of a crop, so perhaps when irrigation is to be practiced it will be most economical to apply a medium quantity at planting time and more through irrigation water as tests indicate a need. The tests should be made regularly on the green plants.

As an illustration, if the planting time application of fertilizer is 1,000 pounds per acre of 2-16-8, about 130 pounds of 62-percent muriate of potash will be required to contain the same quantity of potassium. If after the initial planting time application, there is a need for more in the irrigation water an application of 22 pounds each week for 6 weeks would result in a doubling of the initial application.

Phosphorus Should Be Applied at Planting Time

Experiments conducted during recent years have shown that fertilizers containing phosphorus are much more efficient when applied in bands than when mixed with the soil after a broadcast application. The greater efficiency is largely due to the lesser contact between the fertilizer and the soil, which results in less fixation of the phosphorus into forms not available to plants. Application of phosphorus in solution would result in maximum contact between the phosphorus and the soil and, therefore, fixation of much of the phosphorus into very difficultly available forms.

Another reason why phosphorus cannot be applied efficiently through irrigation water is that the cheaper sources of phosphorus are not readily soluble. Prince and Tiedgens[1] of New Jersey found that much of the phosphate in mixed fertilizers could not be dissolved in water. Even at low concentrations (3 pounds in 50 gallons of water) over 50 percent of the phosphorus in some of the mixtures failed to dissolve. This low solubility of the phosphorus in mixed fertilizer is due to the fact that the phosphorus is supplied as superphosphate. If an attempt is made to apply superphosphate through irrigation water, the undissolved portion must be discarded or forced through the system in suspension. In order to force solid fertilizer through the sprinklers it would be necessary to grind it finer than is generally done and provide some agitation equipment to keep the material in suspension. Even with very finely ground fertilizer there would be serious danger of clogging the sprinklers. Soluble forms of phosphorus are too expensive as sources of phosphorus for large areas.

METHODS OF APPLYING THE FERTILIZER

When using a horizontal centrifugal pump, the most practical method of applying the fertilizer is to draw the solution through the

[1]New Jersey Agricultural Experiment Station, Circular 449, 1942.

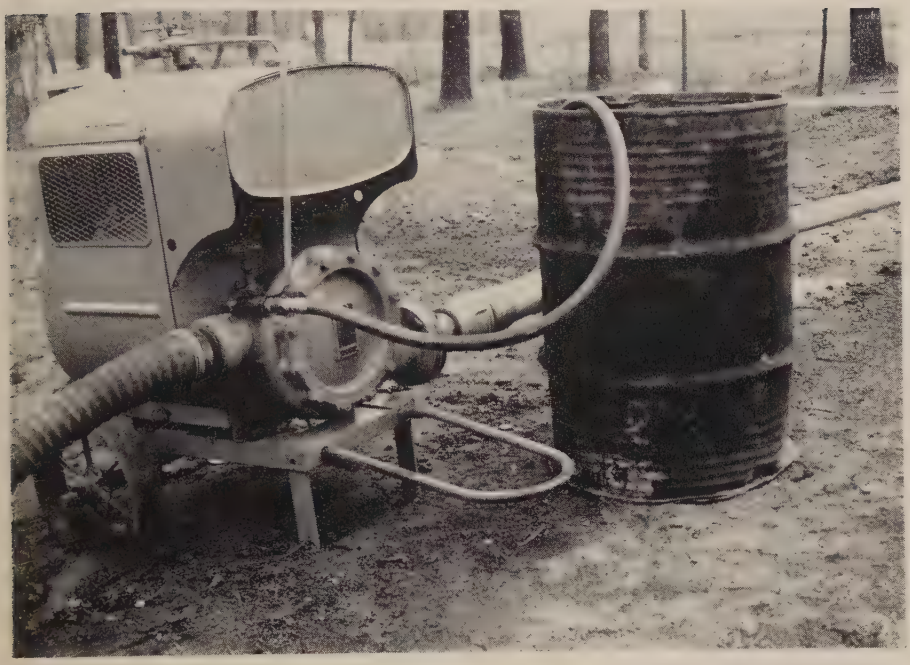

Fig. 1. A portable-type centrifugal pump equipped to apply fertilizer through irrigation water.

intake side while the pump is in operation. The fertilizer thereby enters the stream of water and thorough mixing occurs (Fig. 1).

To make this installation, a pipe fitting or short piece of pipe (¼ inch or larger) is connected at a suitable place in the suction line of the pump. Many pumps have a plug that can be removed and a pipe can be screwed in its place. If that is not possible, the suction line may be drilled and tapped for the size pipe or fitting desired. Next, a shut-off valve is attached and, from the valve, a piece of garden hose about 6 feet in length run into a barrel or other container in which the fertilizer is dissolved. A 55-gallon oil barrel with one end open is usually suitable for this purpose. See Fig. 2 for the installation on one particular pump. The actual fittings required will depend, somewhat, on the size and location of the hole through which the fertilizer enters the pump.

To apply the fertilizer, the desired quantity is measured out and placed in a barrel with sufficient water so that all the fertilizer is thoroughly dissolved.

For any one setting of the irrigation pipe, it is desirable to first

run the water for 15 to 30 minutes. The valve is then opened a small amount so that the fertilizer is slowly drawn in with the stream of water and discharged through the sprinklers. As soon as the fertilizer solution is taken from the barrel, the valve should be closed. The proper opening of the valve is such that 10 to 15 minutes is required to take in the required amount of fertilizer. After the fertilizer has gone through the line, the sprinklers should be run at least an additional 10 minutes in order to wash all the material off the plants.

It is always a poor practice to irrigate at such a high precipitation rate that the water will run off the surface. When applying fertilizer, it is even more important to watch this point as it is impossible to get uniform fertilizer application if the water is allowed to run to the low places.

Before starting the pump, the suction line must be tightly closed. If there are air leaks in the valve or at other points in the suction line, it might be impossible to prime the pump.

When using a deep-well turbine pump, the fertilizer solution must be induced into the irrigation water by other means than that described above. One method that is being used satisfactorily is to tap the pipe line on the discharge side of the pump and again install a

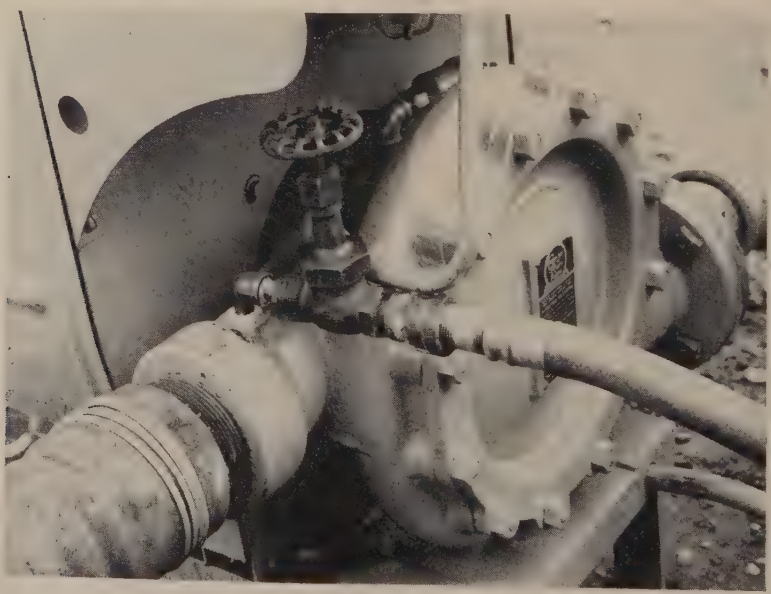

Fig. 2. Fittings used to introduce the fertilizer solution into the intake side of a centrifugal pump.

valve and suitable piping. The fertilizer solution can then be forced into the stream of water under appreciably higher pressure than delivered by the irrigation pump. Some are using a regular spray pump for this purpose and mixing the fertilizer solution in the tank of the sprayer.

QUANTITIES OF FERTILIZER TO APPLY

After deciding on the per acre rate of fertilizer application for one irrigation, the number of pounds needed for a setting of the sprinklers can be determined from Table 1.

Ammonium sulfate is the least soluble of the three nitrogen fertilizers previously mentioned. It is soluble to the extent of 280 pounds in 50 gallons of water. The same amount of water will dissolve 108 pounds of potassium chloride. If great quantities of both potassium and nitrogen fertilizers are applied, owing to high rates or large areas per sprinkler setting, it is desirable to dissolve the fertilizers separately. When combined at high concentrations, these two materials react to form potassium sulfate which is much less soluble.

Fertilizers dissolve quite readily at low concentrations but as the saturation point is approached, considerable stirring is necessary. In such cases, it might be desirable to provide a mixing tank having a larger volume than a barrel.

TABLE 1—*Pounds of fertilizer to use for each setting of a sprinkler line*

Length of line (rods)	Distance line moved per setting (feet)	Rate of fertilizer application (lb. per acre)				
		20	40	60	80	100
20	40	6	12	18	24	30
	60	9	18	27	36	45
	80	12	24	36	48	60
40	40	12	24	36	48	60
	60	18	36	54	72	90
	80	24	48	72	96	120
60	40	18	36	54	72	90
	60	27	54	81	108	135
	80	36	72	108	144	180
80	40	24	48	72	96	120
	60	36	72	108	144	180
	80	48	96	144	192	240

SUMMARY

The application of fertilizer through irrigation water is another method which is theoretically sound for nitrogen and potash but not for phosphorus. It seems to be an especially desirable method for applying nitrogen during midseason. It is suggested that a little nitrogen, all the phosphorus and most of the potassium be applied in bands at planting time and that supplementary nitrogen and potassium be applied when tests or observations indicate a need.

Fertilizer should be dissolved in water in a barrel or other suitable container and introduced into the pipe line while irrigation water is being applied. If the pump is of the centrifugal type, the solution is taken into the intake line. In the case of a deep-well turbine, the solution must be forced into the discharge line under higher pressure than that developed by the pump.

NITROACETATE AND NITRODITHIOACETATES AS POTATO SPRAYS

By J. H. MUNCIE and W. F. MOROFSKY
SECTIONS OF BOTANY ADD PLANT PATHOLOGY, AND ENTOMOLOGY

DURING the last few years many new materials have been developed to replace bordeaux mixture as a spray material. Among these may be mentioned the low-solubility or fixed coppers and more recently the carbamates. While many of these materials have given good results as potato sprays, the search still goes on for even better fungicides.

Preliminary field tests were made on potatoes in 1946 of two new materials, the nitrodithioacetates of zinc and copper, to which DDT[1] or BHC[2] were added as insecticides. These materials showed sufficient promise to warrant further tests in 1947. Results of the tests of the nitrodithioacetates of zinc and copper and of copper nitroacetate are here given as a progress report.

MATERIALS AND METHODS

The new materials supplied by General Chemical Co. will be referred to by the following numbers; 308, copper nitrodithioacetate, 629 zinc nitrodithioacetate and 632 copper nitroacetate. They contained respectively 32.3 percent copper, 33.8 percent zinc and 38.3 percent copper. These were used with either DDT or BHC in control of potato insects.

Fixed copper and bordeaux mixture combined with DDT and BHC and DDT alone were used as checks against the new materials.

The plats planted June 15 to Menominee variety, consisting of four rows 180 feet long, were randomized and replicated three times. Two harvestings were made of the two center rows, 40 feet long. The plats were sprayed at intervals of 10 days beginning July 15,

[1]Dichlorodiphenyltrichlor ethane.
[2]Benzene hexachloride.

ARTICLE 30-57

TABLE 1—*Results with nitro-nitrodithioacetate potato sprays, Lake City 1947, Menominee variety*

Materials and dosage*		Bushels per acre U. S. No. 1**	Total insect counts for season***		Sept. 15
			Leaf hoppers	Flea beetles	Early blight percent infection
†629–308–DDT	1–1–2–100	243.8	12	4	1.0
629–308–BHC	1–1–1–100	246.1	41	12	1.0
††629–632–DDT	1–1–2–100	262.3	23	2	1.5
629–632–BHC	1–1–1–100	232.4	44	8	1.0
629–DDT	2–2–100	256.5	27	9	1.0
629–BHC	2–1–100	241.0	60	7	1.0
308–DDT	2–2–100	254.9	18	1	1.0
632–DDT	2–2–100	255.9	22	1	1.0
Copper–DDT–BHC	3–½–½–100	216.9	14	1	5.0
Genicop	4–100	215.5	15	0	5.0
Bordeaux–DDT	8–4–11/2–100	192.2	16	0	5.0
Bordeaux–BHC	8–4–3–100	242.1	51	3	5.0
DDT alone	1½–100	177.1	13	2	5.0
Check–no spray		248.5	87	107	15.0

*One-half pound of "Filmfast" added to each 100 gallons of experimental sprays.

**Least significant difference—42.4 bushels at 5%: 56.4 bushels at 1%.

***Total count of insects from five sweeps 2–4–6 and 8 days after each of 7 spray applications.

†629 zinc nitrodithioacetate.
308 copper nitrodithioacetate.

††632 copper nitroacetate.

with 7 applications being made before the killing frost of September 23.

No late blight was present. Readings of early blight infection, which was light, were made August 15 and September 5. Insect collections were made from each plat 2, 4, 6 and 8 days after each of the seven spray applications. Insect counts were made from five complete sweeps at each collection. In Table 1, the potato leaf hopper, six-spotted-leaf hopper and others are included under a single heading. Potato insects were of minor importance, and only six Colorado potato beetles were collected from all the plats during the entire season.

The latter part of the season was hot and dry, water being furnished by five irrigations with a whirling sprinkler system delivering approximately one acre-inch of water per hour.

RESULTS

Highest yield of U. S. No. 1 potatoes was obtained from the plat sprayed with a combination of zinc nitrodithioacetate and copper nitroacetate with DDT as insecticide. However, plats receiving any one of the new materials whether used alone or as a combined fungi-

cide had yields significantly higher than those plats sprayed with bordeaux mixture, a fixed copper, Genicop or the insecticide DDT alone. Substitution of BHC in place of DDT with these materials in every case resulted in reduced control of leaf hoppers while effect on flea beetle control was variable.

The combination of DDT and BHC with a fixed copper apparently had no additive effect in reducing either leaf hopper or flea beetle populations below that produced by DDT alone.

Increase in yield of the plats receiving bordeaux plus BHC over those receiving the same material plus DDT cannot be explained on the basis of results obtained from the plats getting these insecticides alone or in combination with other fungicides.

CONCLUSIONS

From these results it appears that the nitrodithioacetates of copper and zinc and copper nitroacetate show considerable promise as potato sprays. Certainly further tests are warranted, especially with other potato varieties and under conditions of heavier insect infestation and incidence of fungus leaf diseases. Although early blight was not severe, these materials held the disease in check better than bordeaux mixture with no decrease in yield. Although insect infestation also was light, the use of benzene hexachloride instead of DDT resulted in lowered insect control, particularly potato leaf hoppers, and in most cases decreased yields of potatoes.

EFFECT OF 2,4-DICHLOROPHENOXYACETIC ACID ON OATS AND BARLEY VARIETIES

By B. H. GRIGSBY and BOYD C. CHURCHILL
SECTIONS OF BOTANY AND PLANT PATHOLOGY, AND FARM CROPS

EXPERIMENTS with 2,4-D on small grains in Michigan and in other states have indicated the possibilities of its use as a selective spray for these crops. While the data point out the value and possibilities of 2,4-D, details regarding its range of effectiveness under different conditions, proper rates of application, and effect upon the crops are still partially or entirely unsolved.

To secure further data on these problems, several varieties of oats, barley, flax, and corn hybrids were planted in 1947 on experimental plats at East Lansing. The field was rather low and in the spring, very wet. Rye, grown as a winter cover crop, had to be plowed down before plantings could be made. All plantings were made after June 1, too late for commercial seedings of oats, barley and flax in this vicinity. However, the authors believed that much could be learned even though yields might be very low, since yields were to be taken only on one variety of oats and one variety of barley. The information presented here pertains only to results with oats and barley.

Spraying was done with a "Jeep"-mounted sprayer equipped with a 50-gallon spray tank, power take-off pump and boom with flat fan-type nozzles. All plats were sprayed crosswise of the seeding. Plats from which yields were taken were drill-width wide and in triplicate. Other plats consisted of a single planting of five rows of each variety.

Three rates of application were made of the sodium salt and ester of 2,4-D when the grain was about 6 inches high. At the same time, plats were sprayed with Dow Selective Weed Killer, a dinitro compound, at two rates. A check plat was left unsprayed for comparison. At a later date (after heading) an additional plat was sprayed with the ester of 2,4-D at the rate of 1¼ pound of actual 2,4-D acid per acre. Germination tests were made of the cleaned seed harvested from the various plats.

ARTICLE 30-58

TABLE 1—*Effect of selective sprays at varying rates and dates upon yield of oats and barley in percentage of check yield*

Treatment	Percent of check*		Treatment	Percent of check*	
	Barley	Oats		Barley	Oats
Sodium salt, light rate	58.9	48.6	Ester, heavy	55.4	67.6
Sodium salt, medium	67.8	62.4	Dow Selective, light	100.9	94.9
Sodium salt, heavy	55.4	55.8	Check	100.0	100.0
Ester, light	42.0	78.3	Dow Selective, medium	75.0	91.3
Ester, medium	67.8	83.3	Ester, light (after heading)	82.0	87.7

*Yield per acre of check: barley—13.6 bushels per acre, oats—25.1 bushels per acre.

RESULTS

Table 1 shows the yields, in percentages of the check, for Bay barley and an unnamed selection of oats, No. 3909.

The plats contained a number of weed species and volunteer plants of red, alsike, and ladino clovers. The clovers survived only in the check plats and in those plats sprayed with Dow Selective Weed Killer. Weeds were not plentiful enough to cause any great reduction in yield of the grain. Not all weed species were killed. However, wild mustard and common ragweed, the predominating species, were killed by all sprays at all rates.

While too much emphasis should not be placed upon the yields, it seems significant that check plat yields were highest. Yields of oats were not affected by Dow Selective Weed Killer at either rate, and yield of barley was not affected by this material at the lighter rate. All other rates and materials reduced yield of the grain under conditions of this experiment.

Table 2 gives the percentage germination of the nine varieties of oats and three varieties of barley tested.

Germination was high for all varieties of barley and for all but two varieties of oats tested. Germination of Bond X, when sprayed with either the ester or sodium salt of 2,4-D, apparently was lowered somewhat from that of the check and the plats sprayed with Dow Selective Weed Killer. Results with Benton oats were irregular but germination in some instances apparently was reduced by the spray treatment.

TABLE 2—*Effect of selective sprays upon seed germination of oats and barley harvested from field sprayed plots*

Varieties	Treatments									
	2, 4-D* Sodium salt			2, 4-D* Ester			Dow Selective Weed Killer		2, 4-D Ester late	Check
	¾ lb. light	1½ lb. medium	2 lb. heavy	¾ lb. light	1½ lb. medium	2 lb. heavy	2 pints per acre	3 pints per acre		
Bay barley	99.6	100.0	99.9	94.3	99.5	99.7	96.2	97.5	98.9	96.3
Spartan barley	94.5	93.5	85.5	95.6	99.5	98.5	98.5	98.0	98.5	92.0
Wisconsin 38 barley	99.0	93.0	97.2	99.5	99.4	98.5	99.0	99.5	99.5	99.5
Mindo oats	98.5	97.0	98.7	96.5	99.0	99.0	100.0	99.0	98.5	99.0
3909 oats	97.4	98.0	93.7	97.5	97.2	92.2	97.2	97.3	97.7	98.9
Benton oats	79.5	69.0	96.0	97.5	90.5	95.5	76.0	90.5	90.0	96.0
Bond X oats	85.5	85.0	79.0	81.0	84.0	85.5	90.0	94.0	85.5	97.5
Clinton oats	91.0	89.5	89.0	91.5	89.5	93.0	90.5	97.5	96.5	96.0
Eaton oats	98.5	94.0	92.5	99.0	99.0	96.0	94.0	99.0	94.5	96.5
Forvic oats	96.0	99.0	99.5	99.5	98.0	97.5	98.5	99.5	99.0	99.5
Huron oats	97.5	93.5	96.0	96.0	98.5	90.0	98.5	100.0	99.0	99.0
Marion oats	99.0	94.0	99.0	99.5	96.0	97.0	99.0	98.5	98.0	.....
Vicland oats	100.0	97.0	100.0	96.5	95.5	91.5	99.4	99.0	98.5	100.0

*2, 4-D equivalent as pounds of 2, 4-D acid per acre in the form of sodium salt or butyl ester.

SUMMARY

1. Oats and barley, sprayed when the plants were 4-6 inches in height, did not show any evidence of injury to vegetative tissue at the rates of ¾, 1½ and 2 pounds 2,4-D acid equivalent per acre.

2. Ragweed, mustard, yellow rocket and rough pigweed were killed by all chemicals at all rates used in these trials.

3. Weed grasses and smartweed were not killed by any of the treatments.

4. Seedling clover was killed by all 2,4-D treatments. Dow Selective Weed Killer did not kill the clover.

5. Germination of barley was not reduced by 2,4-D nor by Dow Selective Weed Killer.

6. Germination of two varieties of oats was somewhat reduced by spraying with 2,4-D. Benton oats were less severely affected than the variety Bond X. These results indicate that there may be varietal differences in the response of small grains to 2,4-D and that testing of all commercially grown varieties is needed before recommendations for spraying these crops can be made. Such tests are proposed for the 1948 season.

SOME CHEMICAL AND PHYSICAL PROPERTIES OF DAIRY CLEANERS

By P. S. LUCAS
SECTION OF DAIRY

THE VALUE of any dairy detergent depends upon its specific physical and chemical properties. The cleaning problems of a dairy products plant, in many instances require different end results and, in some cases, the piece of equipment to be cleaned may not lend itself to harsher or gentler treatment than other pieces of equipment. Some pieces of equipment come into the plant in much worse condition than others. In other cases, the pieces to be washed are so numerous as to require rapid machine action while in some, hand cleaning is required. There is, for instance, the milk bottle which will endure harsher treatment than the milk can or tinned copper surface. Painted surfaces and hand-cleaned materials require the use of a cleaner mild in action. Floors, because of the type of soil, usually require special cleaners. For those reasons, the statement is often made that no one cleaner can answer all purposes in the plant.

Of cleansers used in dairy plants, soaps cannot be employed on equipment coming into contact with milk because of the film they leave and because of their expense. Owing to the increasing amount of attention now being given this subject, new types of detergents are being developed and introduced at very frequent intervals. These vary radically from each other in the means by which they accomplish detergency. Among these products are the wetting agents. Washing powders placed on the market under brand names are usually mixtures of these many detergents selected to add their contribution of properties to the trade marked cleaner. Similarly, home-made mixtures may be used to accomplish the same results. It is for the purpose of evaluating some of these properties that this article has been prepared. It should be remembered that these mixtures, whether compounded commercially, or by the dairy plant, vary necessarily in their economy, speed of action, availability of basic products, and the usage to which the product is to be put. The usage

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to which the product is put depends upon its effect on metal, glass, painted surfaces, tile and cement, the type of soil to be removed, whether for hand or machine washing, and type of washer such as soaker or brush-type bottle washers. If the user knows the properties of the ingredients of a mixture he may be able to select those types best adapted to the purpose of the cleaner.

The earliest cleaners used were the moderately harsh alkaline types and caustic soda for milk bottle washing. Use of these two was followed by a mixture of soda ash with bicarbonate of soda which was an advancement but had its disadvantages. This was followed by the introduction of trisodiumphosphate, followed by the introduction of such products as sodium metasilicate, the complex phosphates, weak acids, sodium aluminate, and the wetting agents. Newest of the cleaning agents are the quaternary ammonium compounds, the properties of which have not, at this date, been completely investigated. The dairy plant manager, in many cases, has become confused by the new data made available through study of these new products. In general, however, the simpler facts may be well understood by the user and may be intelligently applied either to the selection of the proper detergent or in the mixing of basic materials for preparation of a cleaner for a special purpose.

CLEANERS VARY GREATLY IN PROPERTIES

So far as this report is concerned, several cleaners have been selected. Many contain basic materials used in cleaners and commercial combinations. They range in reaction from acid to neutral to highly alkaline. A few have been very highly buffered, and an effort has been made to measure the amount of buffering by continuous neutralization (Table 3). An examination of the tables which follow will show, as would sales, that the trend has been away from the highly buffered combinations and from excessive alkalinity to solutions more nearly neutral, which the use of wetting agents have made possible. This has been made possible by the ability of the wetting agent to loosen oily films without resorting to the more drastic methods of saponification and emulsification. While it has not been definitely proved, it might be assumed that action of the wetting agents would result in the formation of less milk- and waterstone.

In Table 1 shown below, the results are given of titrations made of each cleaner in strength of 0.5 percent in neutral distilled water.

TABLE 1—*Chemical reaction and pH of 0.5-percent solutions (10-ml. portions used)*

No.	Product	Ml. to phenol-phthalein	Ml. to methyl orange	pH
1	Mikro San	0.75	.....	3.11
2	Dolco Tilebrite	0.7	.....	2.5
3	Nacconol N.R	0.0	0.0	6.76
4	Aerosol O.T. 100	0.0	0.06	6.5
5	Calgon	0.0	1.00	7.31
6	Kleer-Mor	0.28	0.58	9.33
7	Wyandotte Cleaner	2.34	4.40	9.62
8	Wyandotte Detergent	0.38	0.75	9.65
9	Solvay Super Cleaner	2.24	4.84	9.79
10	Solvay No. 600	2.44	3.55	10.38
11	Mathieson Nufos	2.97	2.82	10.67
12	Diversey Dumore	2.90	3.22	10.72
13	Diversey Diversol	0.85	.....	11.01
14	Solvay Milkstone Remover	2.51	1.97	11.19
15	Trisodiumphosphate	1.52	1.55	11.31
16	Diversey Novex	4.89	3.63	11.46
17	Calgonite	1.55	1.57	11.50
18	Metasilicate (Metso)	4.46	0.31	11.72
19	Alkali Special	12.06	0.22	12.43
20	Sodium Aluminate	4.98	.....	11.00
21	Neo Suds	1.20	2.85	9.40
22	F 100	1.60	1.98	11.09
23	Pyramid	1.94	2.58	9.84
24	Klenzade "CBS"	.90	3.80	10.40
25	Wyandotte G.L.X	2.9	6.1	10.78
26	Calglo	.....	0.5	7.07
27	Klenzade Super Six	1.4	3.1	11.28
28	Solvay No. 800	2.2	5.6	9.10
29	Mathieson Briquets (Old Style)	3.0	5.7	11.09
30	Clenitol	.....	1.0	7.55
31	Tetraphosphate	.3	2.0	8.35
32	Tetratripolyphosphate	.7	3.3	9.29
33	Tetrasodium pyrophosphate	1.4	4.5	9.94
34	Minn. U. Formula No. 1	3.6	4.6	11.77
35	Minn. U. Formula No. 2	2.4	3.85	11.30
36	Special Formula No. 1	2.4	3.6	11.51
37	Soda ash	4.2	8.5	10.91
38	Wyandotte Can Wash	3.75	6.8	10.99
39	Klenzade Can Wash	3.3	6.9	11.21

A 10-ml. portion of each was titrated against either tenth-normal hydrochloric acid or sodium hydroxide, and each was tested for pH. Titration results were recorded with two indicators: phenolphthalein and methyl orange. The amount (in ml.) of titrating agent required to neutralize, using phenolphthalein as the indicator indicates the amount required to neutralize all of the caustic, plus one-half of the sodium carbonate or soda ash, but none of the bicarbonate that might be present. The column headed "methyl orange" represents the amount required to neutralize the remaining half of any soda ash as well as all the bicarbonate originally present. Doubling this latter reading, therefore, gives the total soda ash plus sodium bicarbonate value. The total of both readings would give the total alkalinity. It is real-

ized that the presence of other basic detergents such as phosphates and silicates may interfere with such titrations, in which case the procedure must be modified.

These data, secured as described in the paragraph above, show the relative alkalinity of the detergents mentioned. Higher alkalinities may be used on equipment which is resistant to the action of strong alkalies, such as glass. Highly alkaline detergents may not safely be used on metals or in washing requiring hand cleaning. Strong alkalies favor the formation of milkstone and waterstone. The occasional use of acid cleaners has a tendency to remove such stone. In preparing a washing agent for the cleaning of metals or for hand washing, therefore, the user should select powders not possessing too high alkalinity.

The acid-base cleaners and the two wetting agents obviously would contain no carbonates. The first two mentioned are but weakly acid, and the second two are neutral, as is No. 5 which is sodium metasilicate. Five cleaners, numbers 7, 9, 10, 12, and 16 carry relatively large quantities of the buffer sodium bicarbonate. As shown previously, when a washing powder mixture contains only soda ash and bicarbonate, these act to hold the pH or alkalinity at a constant level of strength until the buffer is used up. The chief value of a buffer in a washing powder, however, is for use in hand washing and for the farm. Where machine washing of bottles is practiced, the stronger alkalies will clean more thoroughly. The column headed "pH" has been arranged for the first 18 samples largely in order of ascending values. Those values below 6.8 represent acid reaction and those above that value, alkaline reaction. Values greater than 12 for pH are of little use since the range of error is so great at that degree of alkalinity. It is assumed that that of special alkalines used in bottle washing will range from 12.0 to 12.6. In general, the harshness of the effect of cleaners increases with an increase in pH. A notable exception may be seen in the case of sodium metasilicate in its action on metals. It is difficult to explain why this is so, but a logical explanation seems to be that it forms a protective film of molecular thickness on the wall of the utensil. Another explanation might be the presence in the cleaner of an inhibiting agent such as sodium aluminate which acts as a buffer. When sodium metasilicate was used alone in a mechanical milk bottle washer, the gears became tightened to such an extent that the chains were broken. Presumably this was due to its poor lubricating properties. When used to no greater ex-

tent than 30 percent of the cleaner used, the results were satisfactory. When special alkalies were used in amounts greater than 3 percent, the tendency was to soften and damage the glass of milk bottles as well as to bleach the colors in any pyroglaze letters on the wall of the bottle. A 4-percent caustic solution had this effect upon glass milk bottles and it resulted also in saponification of any butterfat present. Such soap caused excessive foaming and difficult rinsing because of the soapy film left. The higher the temperature of the washing solution, the greater was this effect. A 3-percent solution of caustic possesses sufficient sanitizing powers and a 2½-percent solution is sufficient if a chlorine rinse is used on the bottles.

TABLE 2—*du Nuoy Tensiometer tests of 0.5-percent solution*

No.	Product	Dynes at 72° F.	Dynes at 145° F.
1	Mikro San	35.6	30.0
2	Dolco Tilebrite	69.9	67 5
3	Nacconol N.R.	33.7	32.2
4	Aerosol O.T. 100	29.6	28 5
5	Calgon	72.7	70.0
6	Kleer-Mor	31 6	30.2
7	Wyandotte Cleaner	71 2	67.2
8	Wyandotte Detergent	26.1	25 6
9	Solvay Super Cleaner	71.3	62.5
10	Solvay No. 600	32 9	30.0
11	Mathieson Nufos		
12	Diversey Dumore		
13	Diversey Diversol	36.7	32.9
14	Solvay Milkstone Remover	71.4	68.4
15	Trisodiumphosphate	66.4	63.6
16	Diversey Novex	63.7	68.7
17	Calgonite	71.0	51.6
18	Metasilicate (Metso)	67.1	58.9
19	Alkali Special	71.7	67.0
20	Sodium Aluminate	60.4	55.6
21	Neo Suds	73.0	66.1
22	F 100	32.7	31.2
23	Pyramid	38.5	33.0
24	Klenzade "CBS"	34.6	31.3
25	Wyandotte G.L.X	30.8	30.2
26	Calglo	34.5	31.7
27	Klenzade Super Six	35.5	29.5
28	Solvay No. 800	40.9	35.9
29	Mathieson Briquets (Old Style)	41.5	35.1
30	Clenitol	71.0	66.8
31	Tetraphosphate	32.5	31.2
32	Tetratripolyphosphate	55.5	51.5
33	Tetrasodium pyrophosphate	69.6	55.9
34	Minn. U. Formula No. 1	66.0	50.9
35	Minn. U. Formula No. 2	34.6	31.9
36	Special Formula No. 1	34.5	31.5
37	Soda ash	40.8	35.8
38	Wyandotte Can Wash	53.7	58.0
39	Klenzade Can Wash	63.0	48.8
		34.7	31.0

SURFACE TENSION

Wetting agents, especially, among dairy detergents have the power of reducing surface tension and herein lies their value. If used alone, they cause excessive foaming in machines where the agitation of the cleaning solution is violent. Used alone their strength is rapidly dissipated also by the dairy products clinging to the sides of dairy containers.

Surface tension may be measured by means of a du Nuoy tensiometer and the results tabulated in Table 2 were so obtained. For these a 0.5-percent solution was prepared and determinations made at 72° F. and 145° F. Since washing is done at nearer the latter temperature, the latter values should be more significant in rating the surface tension breaking powers of the detergent.

The lower the tensiometer readings the greater is the power of the cleaner to reduce surface tension. Values below 40 show the considerable employment of surface tension reducing chemicals in the cleaner. Many modern cleaners make great use of such agents together with soil removing agents.

BUFFER ACTION

Several 1-percent solutions of cleaners used were checked for maintenance of strength, as recorded by the pH test after the addition of 1-ml. portion of tenth-normal neutralizer. The purpose has been to check the degree of buffer action after each such addition. The differences in the results has been so great that the break in strength cannot be shown in graphs. The figures are given in Table 3.

Those cleaners previously mentioned as containing sodium bicarbonate are shown to be heavily buffered. This is a desirable characteristic, especially for those used in hand washing since the sodium carbonate, by feeding sodium ions into the mixture, maintains a constant strength; therefore, uniform washing results until the strength of the buffer begins to fail. With a washing powder not buffered, the strength is gradually dissipated from the start of the operation and it is reasonable to expect that uniform results will not be obtained unless the solution is constantly reinforced with new cleaner. On the other hand, it is not important to give much weight to the buffering of a solution since the carbonate cleaners are not, at the present time, especially

TABLE 3—*Dilution (ml.) required to reduce a 1.0-percent solution to pH 11, 10, 9, and 8*

No.	Product	From pH	Ml. 0.1039 N. HCL to reduce pH to:			
			11	10	9	8
1	Mikro San	3.11	.....	.....	.....	.....
2	Dolco Tilebrite	2.5	.....	.....	.....	.....
3	Nacconol N.R.	6.76	.....	.....	.....	.....
4	Aerosol O.T. 100	6.5	.....	.....	.....	.....
5	Calgon	7.43	.....	.....	.....	.....
6	Kleer-Mor	9.61	.....	.....	3	5
7	Wyandotte Cleaner	9.80	.....	.....	16	22
8	Wyandotte Detergent	9.75	.....	.....	14	20
9	Solvay Super Cleaner	9.72	.....	.....	16	25
10	Solvay No. 600	10.84	.....	8	19	25
11	Mathieson Nufos	10.84	.....	10	25	31
12	Diversey Dumore	11.21	5	14.5	27	32
13	Diversey Diversol	11.31	5	9	10	11
14	Solvay Milkstone Remover	11.30	7	14	21	23
15	Trisodiumphosphate	11.61	11	15	17	19
16	Diversey Novex	11.76	13	24	39	44
17	Calgonite	11.45	10	15	16	17
18	Metasilicate (Metso)	11.83	19	27	37	42
19	Alkali Special	12.64	111	115	116	116.5
20	Sodium Aluminate	11.51	3	16	35	40
21	Neo Suds	9.65	.....	.....	7	11
22	F 100	11.45	6	10.5	14	15.5
23	Pyramid	10.15	.....	3	15	20.5
24	Klenzade "CBS"	11.2	1	7	12	20
25	Wyandotte G.L.X.	11.2	2	11	25	29
26	Calglo	7.0	.....	.....	.....	.....
27	Klenzade Super Six	11.5	7	13.5	16	21
28	Solvay No. 800	10.05	.....	1	16	20
29	Mathieson Briquets (Old Style)	12.1	7	18	29	32.5
30	Clenitol	7.46	.....	.....	.....	.....
31	Tetraphosphate	8.0	.....	.....	.....	.....
32	Tetratripolyphosphate	9.4	.....	.....	.....	.....
33	Tetrasodium pyrophosphate	10.06	.....	.....	1	6
34	Minn. U. Formula No. 1	11.85	14	23	2	11
35	Minn. U. Formula No. 2	11.5	1	7	33	38
36	Special Formula No. 1	11.62	4	10	14.5	19
37	Soda ash	10.72	.....	11	20	22
38	Wyandotte Can Wash	11.15	1	12	34	41
39	Klenzade Can Wash	11.9	7	24	23	25.5
					36	43

popular, because of spotting of equipment on drying, difficulty in rinsing, and their uncertain detergency powers.

In a general way, any plant wishing to make up its own cleaner could very well select an acid cleaner for use at weekly or bi-weekly intervals to remove milkstone. If the powder used is to be mixed in the plant, cleaning compounds for hand and metal washing, should contain an alkalinity no greater than 10.6 percent. For bottle washing, the cleaner should carry sufficient chemical to soften the water, and, in addition, sufficient alkali to make up a 3-percent solution. The more nearly neutral the washing powder, the gentler will be its effect

upon metals, especially tin and aluminum. When, in the past, a considerable alkalinity has been thought necessary for proper cleaning, the addition of wetting agents to the product will considerably reduce the necessity for it. While there are hundreds of wetting agents, these are by no means of equal value in dairy cleaning. A sufficient number, however, are adapted to this type of detergent action, so that selection is possible.

These values as buffers are given in Table 3.

Perhaps more logical compounding of dairy cleaners may be done, making use of the chemical's particular properties as recorded in the tables.

PACKING HOUSE TRIALS TO REDUCE PEACH-ROT

By H. A. CARDINELL and A. E. MITCHELL[1]
SECTION OF HORTICULTURE

"In New York City, crates of southern peaches amounting to over 250 cars a year are sold below the market because they do not meet the usual quality requirements of the trade. Some of these peaches have brown rot, some are moldy, some are green or overripe; a large number are bruised. These conditions are among the commoner causes of sale at a mark-down price."

EXCEPT FOR the fact that the foregoing statement was published in 1929 as a joint study between the U. S. Department of Agriculture and the New Jersey State Agricultural Experiment Station,[2] it could apply to many states, many cities and many years. Those factors continue to plague the fresh peach market. The season of 1947 was no exception.

The severe outbreak of brown-rot in many Michigan orchards in 1947, resulting in the failure of most spray schedules to cope with it, should not soon be forgotten by growers, shippers and receivers of last year's peach crop. The expected carry-over of brown-rot inoculum in Michigan orchards gives added interest to results of the treatments used last season to improve the market quality of Michigan peaches. It is thought that a brief report of a process named "Stericooling" by the manufacturer, and tried last season for the first time in Michigan, would be of interest to the perishable produce industry. The commercial test in Michigan was entirely with peaches. Further trials contemplated for 1948 will include certain vegetables and fruits.

[1]Acknowledgment: Appreciation is hereby expressed to Dr. C. G. Barr and others of the John Bean Division of Food Machinery Corporation, officers and personnel of the Millburg Growers Exchange and the Sodus Fruit Exchange for the opportunity to make these preliminary tests; to the Michigan Ice Industries Association and its secretary, Mr. William J. Campbell; to the Brown Ice and Coal Company of St. Joseph for ice and ice handling equipment; to Dr. M. E. Cravens, Jr., of the Department of Economics for lending a helping hand in many a rush period and for supplying Consumer Report cards on distant shipments of treated packages; and to the authors' colleagues in the Department of Horticulture for valuable suggestions.

[2]Factors Affecting the Price of Peaches in the New York City Market. Harry S. Kantor. U. S. D. A. Tech. Bull. 115, p. 24, Apr. 1929.

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The Millburg Growers Exchange treated about 7,000 packed bushels of Halehaven and Elberta peaches in an "F. M. C. Steri-cooler". This required 45.5 tons of artificial ice, or about 13 pounds per bushel of peaches, to refrigerate to an average fruit temperature of about 42° F.

EQUIPMENT AND METHODS USED IN HYDROCOOLING

By previous arrangement between the John Bean Division of the Food Machinery Corporation, and the Millburg Growers Exchange, the Section of Horticulture had an opportunity to cooperate in testing a piece of equipment and a method new to Michigan. It consisted of a tank, 25 by 8 feet, containing some 2,000 gallons of ice

Fig. 1. Wooden boxes "faced and filled" with peaches are shown coming out of the machine after being hydrocooled with ice water containing a chlorine-type germicide, "Hypo-Clor". Consumer Report form postcards were placed in many of the packages before they were conveyed to the lidding machine and into the cold storage rooms of the Millburg Growers Exchange, Millburg, Michigan.

Fig. 2. The "F. M. C. Stericooler" was too large for the doors of the packing house, hence it was placed alongside the building. A roller conveyor brought packed fruit from the packing tables to the machine. In this view as one man placed pad and cover on the baskets, they were rolled into the ice refrigerated truck, shown at the right. The ice crusher and conveyor, shown on the left, carried crushed ice to the machine as needed to maintain the temperature of the solution at 32° F.

water, in which a chlorine-type germicide was added. A pump lifted the treated ice water and distributed it over a perforated metal ceiling.

Packed wooden containers, without pad and cover, were placed on the slow moving conveyor that carried them through the 25-foot machine. The rate of travel through a torrential downpour of treated ice water determined the temperature of the produce when it reached the exhaust end (Fig. 1). As the conveyor slid a row of packages onto a metal apron, the pads and covers were fastened in place and the fruit traveled over roller conveyors to a waiting truck or into the cold storage room (Fig. 2). Crushed ice was conveyed to the machine as needed to maintain 32° F. in the solution.

For the experimental treatment the germicidal chlorine agent[1] was maintained near 130 parts per million by means of frequent titration tests.

[1] "Hypo-Clor".

RAPID PRECOOLING

Lloyd and Newell[1] state that, "Brooks and Cooley found that the rotting of peaches was greatly accelerated by delay in reducing the temperatures. With peaches that were punctured and then dusted with Rhizopus spores, a delay of 24 hours at a temperature of 25° C. (77° F.) before storing at 7.5 ° C. (45.5° F.) gave the rots a lead of 5 days over similar inoculations on peaches, that were delayed but 12 hours before storing at the same temperature."

The precooling device herein described and illustrated, uniformly lowered the temperature of all the peaches. It accomplished in 15 minutes what standard refrigerator cars, most refrigerated trucks and most cold storage rooms accomplish in removing field heat from a volume of warm fruit within 50 to 70 hours.

In order to approach the rate of fruit packing, the conveyor speed was set to carry packages at the rate of about 200 bushels an hour. At this conveyor-gear-ratio, peaches testing 80° F. as they entered the machine left the other end at a temperature of about 45° F. The day (October 2) the experimental samples were packed, the temperature of the air was only 64° F. and the flesh temperature of the fruit was 56° F. Therefore, the 15-minute exposure to the 32° F. solution resulted in a flesh temperature of 38° F. as the peaches left the machine.

METHOD OF TAKING SAMPLE

Because this was a commercial installation in which some 7,000 bushels of Halehaven and Elberta peaches were treated, it was not possible to make a complete test run until October. On the first day of October, a large load of Elberta peaches was brought to the packing house of the Millburg Growers Exchange. The entire load was put through the brush-defuzzer, wherein the fruit was treated with dusting sulfur to which 10 percent of "Zerlate"[2] had been added, as was standard treatment in that packing house. As the packers packed the fruit in bushel baskets, some of the packed bushels were put through the machine, and other bushels were set aside with only the brusher-duster treatment.

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[1]Some Factors Influencing the Keeping Quality of Fruit in Transit. J. W. Lloyd and H. M. Newell, Ill. Agr. Exp. Sta. Bull. 350, p. 452, 1930.

[2]DuPont's "Zerlate", a proprietary name for 70 percent zinc dimethyl dithiocarbamate.

The fruit of the two treatments was divided into two lots. Half of the fruit of each treatment was hauled to the College and held at room temperature (75° to 80° F.) for 7 days, then examined for spoilage. Likewise, the remaining bushels of each treatment were placed at 40° F. in the cold storage room of the Millburg Growers Exchange. These baskets were held in cold storage for 7 days, then hauled to the College and placed at room temperature for 4 days, before being examined for spoilage. The object of the holding periods 7 and 11 days, respectively, before determining the result, was to simulate conditions Michigan peaches must encounter, with and without refrigeration, in distant shipments, and the time lapse for distribution to stores and for retail sale.

The peaches represented by Table 1 were grown on one farm. They were harvested October 1, hauled to the packing house of the Millburg Growers Exchange that evening, and were packed the following morning. In Michigan, much of our fruit is not precooled and a considerable amount is transported in unrefrigerated trucks. Although Lot 1 was precooled to 38° F., it traveled to East Lansing in an unrefrigerated truck with the unprecooled fruit of Lot 2. It is reasonable to assume that the temperature of the two lots must have been equalized within some 24 hours after leaving the packing house. It is gratifying to note that the combined treatment called "Stericooling" by the manufacturer, did reduce the spoilage as compared with dusting alone even for so long a time as 7 days without refrigeration.

Very few would be surprised at the results obtained with lots 3 and 4. Rapid precooling and refrigerated storage has seldom failed to reduce the growth and development of peach-rotting organisms. In the case of Lot 3, the peaches were already at or below the temperature of the cold storage room after they came out of the machine.

TABLE 1—*Treated ice water versus brush-dusting of Elberta peaches*

Method of treatment and subsequent handling	Rotted fruits	Sound fruits	Percent rots
Lot 1—Treated with 32° F. ice water plus "Hypo-Clor" germicide, held 7 days at 75 to 80° F. room temperature	466	723	39
Lot 2—Brushed and dusted with dusting sulfur plus 10 percent "Zerlate", 7 days at 75 to 80° F	701	443	61
Lot 3—Treated with 32° F. ice water plus "Hypo-Clor" germicide, held 7 days at 40° F. plus 4 days at 75 to 80° F	183	615	23
Lot 4—Brushed and dusted with sulfur and "Zerlate", held 7 days at 40° F. plus 4 days at 75 to 80° F	344	438	44

Lot 4, on the other hand, was at air temperature (64° F.) and had to lose 16° F. of flesh heat (56° F.) before reaching the temperature of the storage room. As this experiment was a test of two commercial packing-house treatments against spoilage, it gives no direct answer of the portion of rot reduction that might be credited to ultra-rapid precooling and what could be credited to the "Hypo-Clor" incorporated with the refrigerant. There is, however, some indication of the probable benefit exerted by the germicidal agent. After the fruit of Lot 1 reached the temperature of the fruit of Lot 2, both lots were held at 75° to 80° F. for 7 days prior to making the counts shown in Table 1. The 22-percent better control in Lot 1 appears to the credit of "Hypo-Clor" over that of the sulfur-"Zerlate" dust treatment.

PEACH-ROT IN RELATION TO POINT OF ENTRANCE

While examining each of the 3,910 peaches, it was thought worth while to record each spoiled peach in terms of the place of entrance of organisms. These data are recorded as Table 2, lots 1 and 2, and Table 3, lots 3 and 4.

It is obvious that there were two vulnerable means of entrance for the rot causing organisms: the stem end and where an infected

TABLE 2—*Elberta peaches held at 75 to 80° F. for seven days*

Source of rot	Lot 1		Lot 2	
	Precooled plus "Hypo-Clor"		Brushed-dusted, not precooled	
	Number	Percent	Number	Percent
Sound fruit	720	60.7	443	38.7
Stem end	236	19.9	386	33.7
Insect injury	000	00.0	1	.1
Skin rupture	18	1.5	7	.6
Contact with rot	194	16.4	291	25.4
Bruise	18	1.5	16	1.4

TABLE 3—*Elberta peaches stored seven days at 40° F. plus four days at 75 to 80° F.*

Source of rot	Lot 3		Lot 4	
	Precooled plus "Hypo-Clor"		Brushed-dusted, not precooled	
	Number	Percent	Number	Percent
Sound fruit	615	77.1	438	56.0
Stem end	124	15.5	239	30.6
Insect injury	000	00.0	000	00.0
Skin rupture	9	1.1	14	1.8
Contact with rot	45	5.6	72	9.2
Bruise	5	.6	19	2.4

peach came in contact with other specimens. Refrigeration at 40° F. did not greatly reduce the infection at the stem end of the fruit. The combined hydrocooling and prophylactic action of the "Hypo-Clor" compound considerably reduced the percentage of infected fruit as compared with dusting the fruit as it passed through the defuzzing unit.

Holding the fruit at 40° F. did reduce the percentage of infection classified as resulting from contact with rotted fruit as indicated in Table 3.

No attempt was made to determine what organisms were responsible for the decay. It was assumed that the brown-rot fungus[1] was the dominant organism, but that blue mold and black mold also took their toll. Brooks and Fisher,[2] reporting some 29 years ago on "Transportation Rots of Stone Fruits as Influenced by Orchard Spraying," had these pertinent conclusions to make. They state: "With all the rots temperature has been an extremely important factor . . . *Rhizopus* (black-mold rot) was entirely eliminated at the lower temperature (41° F.) and *Penicillium* (blue-mold rot) and *Monilia* (brown-rot) were greatly reduced."

DISCUSSION

The severity of the brown-rot fungus as exhibited in many Michigan peach plantings in 1947, makes it difficult to imagine a more severe test for any treatment.

Devices for hydrocooling perishable comestible products in preparation for a long haul from Pacific Coast areas have been in use for several years. The summer of 1947 was the first time that a machine devised for hydrocooling and treating certain produce was brought to Michigan for a commercial test. The machine called the "F. M. C. Stericooler" is a product of the Food Machinery Corporation. One of these units was installed by the John Bean Division of Food Machinery Corporation at the packing house of the Millburg Growers Exchange, to be tested against peach-spoiling organisms of harvested fruit.

The tests herein reported were conducted in order to assist in obtaining a preliminary measure of the effectiveness of the treated ice water on Elberta peaches, when given a 15-minute exposure. The results shown in Table 1 indicate a marked reduction in rot control

[1]*Monilinia fructicola (Sclerotinia fructigena).*

[2]Brooks, Charles and Fisher, D. F. Transportation Rots of Stone Fruits as Influenced by Orchard Spraying. Reprint G-257, Jour. of Agr. Res., Vol. XXII, No. 9, p. 477. November 26, 1921.

in favor of the "Stericooler" treatment, as compared with the more common packing house method of dusting the fruit with a common fungicide. The percentage of rot may appear high as compared with that in other seasons, but it should be remembered that brown-rot disease was unusually severe at blossom time and was not brought under control in infected orchards regardless of the spraying program. The orchard from whence the test fruit came was given its last spraying the day before picking started, but some brown-rot infected fruit was removed by the sorters after the fruit reached the packing house. Under such conditions, it is logical to assume that some infected fruit went into these packages that showed no external evidence of being infected. If this assumption is accepted, it may account for the relatively high percentage of rotted fruit regardless of precooling, germicidal treatments or subsequent cold storage temperature.

The location of entrance of rot, shown in tables 2 and 3, indicates two vulnerable sources of entrance by the organisms. The rupture of skin, where the fruit separates from the branch, is the point of highest infection. Second only to the "stem end" is the point of contact between an infected fruit and adjoining fruit.

In each case, with or without subsequent refrigeration, the treatment in the "Stericooler," wherein all the peaches were quickly reduced to 38° F. by the germicidal ice water, greatly reduced the amount of infection. Prior to these tests, no fungicide or combination of fungicides has proven to be superior to certain grades of dusting sulfur, as a packing house treatment for peach-rot organisms. Hydrocooling, with "Hypo-Clor" as a germicidal supplement, greatly reduced the amount of decay as contrasted with commercially packed peaches treated with dusting sulfur in which 10 percent of "Zerlate" was incorporated.

SUMMARY

Commercially packed Elberta peaches in wooden bushel baskets were treated in an "F. M. C. Stericooler" with 32° F. ice water in which a chlorine-type germicide—"Hypo-Clor"—was held at 130 parts per million. Similar lots were treated with dusting sulfur, in which was incorporated 10 percent of "Zerlate," a standard treatment in the packing house of the Millburg Growers Exchange. The treatment afforded by the "F. M. C. Stericooler" showed superior control of peach-rotting organisms over the packing house dusting treatment.

Peaches held in cold storage, following the two treatments, showed less spoilage than lots not refrigerated after treatment.

A SIMPLE DEVICE FOR APPLYING GROUND SPRAYS

By C. L. HAMNER and LOREN D. TUKEY
SECTION OF HORTICULTURE

THE INCREASED USE of chemicals in weed control has emphasized the need for versatile spray equipment. When 2,4-D is used at the rate of 1 to 1½ pounds per acre it has usually been applied in 150 to 200 gallons of water, the water merely serving as the carrier for the toxicant. Because of the inconvenience in using such large volumes of water, the present trend has been towards concentrated solutions, that is, applying the same amount of chemical per acre, but reducing the amount of water. The successful application of 2,4-D in as low as 5 to 10 gallons per acre has been reported.

The increased use of 2,4-D as a selective herbicide on lawns, golf courses, parkways, pastures, corn fields, and so on, has greatly increased the need for a sprayer of low cost that can apply concentrated solutions. To meet this need an inexpensive, easily-operated sprayer has been constructed at Michigan State College from a common 3-gallon hand sprayer (Fig. 1), mounted on a hand garden cultivator and equipped with a spray boom. Necessary alterations are small and inexpensive. The equipment needed is as follows:

1. Cultivator
2. 3-gallon hand sprayer
3. Gasoline filter
4. Boom
    a. 6—⅛-inch x 12-inch nipples
    b. 7—⅛-inch x 6-inch nipples
       5—⅛-inch x 1-inch nipples
    c. 9—⅛-inch elbows
    d. 4—¼-inch to ⅛-inch reducing elbows
    e. 5—⅛-inch tees

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Fig. 1. Sprayer with pipe attachment to boom; gasoline filter can be used where concentrate sprays are used with small opening spray nozzles.

f. 2—⅛-inch plugs
g. 1—¼-inch coupling
h. 1—¼-inch to ⅛-inch reducer sleeve
i. 18 inches of heavy, small-diameter rubber hose
j. 4—¼-inch nozzles

5. 12 inches of angle iron
6. 5 feet of strap iron
7. 8—¼-inch by 1½-inch bolts
8. 8—¼-inch nuts and washers
9. A little wire

Any garden cultivator will do, but it has been found that a metal cultivator similar to that shown in Fig. 2 is especially adaptable. The spray tank is mounted as shown in Fig. 3. Necessary alterations are as follows: Invert the two horizontal metal bars which are connected to the wheel at one end and to which the cultivating equipment is commonly attached. Spread the bars so that they will provide a broad base for the tank to rest upon. The two metal bars which extend downward from the handles are moved forward at the bottom as shown in Fig. 2. It will be necessary to shorten the bars and bore a hole in each. The two short pieces of metal bar can be used for the construction of suitable rear legs. A short piece of angle iron is bent in the form of a horseshoe to hold the bottom of the tank in place. It may be bolted or welded to the cultivator (Figs. 2 and 3). The upper part of the spray tank is supported by a "U" of strap iron at the back and by a straight piece of strap iron in front. When they are bolted together they hold the tank snugly (Figs. 2 and 3).

Fig. 2. Cultivator with braces for spray tank to rest upon.

Fig. 3. Close-up of spray boom showing adjustable spray arm; this permits a flexible control of spray on row crops.

The shut-off valve is located near the left handle for convenience in operation. A gasoline filter is used to remove all large size particles that might clog the nozzles. A ⅛-inch pipe and fittings connect the tank with the filter (Fig. 1). A short piece of heavy, small-diameter rubber tubing is used to connect the filter to the boom so as to facilitate adjustment of the boom at the desired height from the ground. The boom may be clamped to the cultivator in any convenient location (Fig. 4).

The boom is constructed of ⅛-inch pipe and fittings. Nozzles may be placed 12 or 24 inches apart (Figs. 3 and 4). Fan-type nozzles obtained from the Monarch Manufacturing Company, Philadelphia, are satisfactory. The sprayer will cover a swath 8 feet wide. By merely changing the size of the opening of the spray nozzle, delivery rates may be controlled. With a small delivery rate and by walking rapidly, it is possible to cover several acres in a day, using as low as 3 gallons of concentrated spray material per acre.

A sprayer of such simple construction can be easily adapted to a specific crop such as corn and gladioli where 2,4-D is to be applied between the rows and away from the crop.

In addition to its use for applying 2,4-D, this type sprayer can readily be used for applications of other materials in concentrated form such as insecticides, fungicides and hormones. It is believed that this new adaptation of a hand sprayer may have large-scale use where concentrated sprays are used. It should also prove definitely superior to the conventional hand sprayer in the application of dilute sprays.

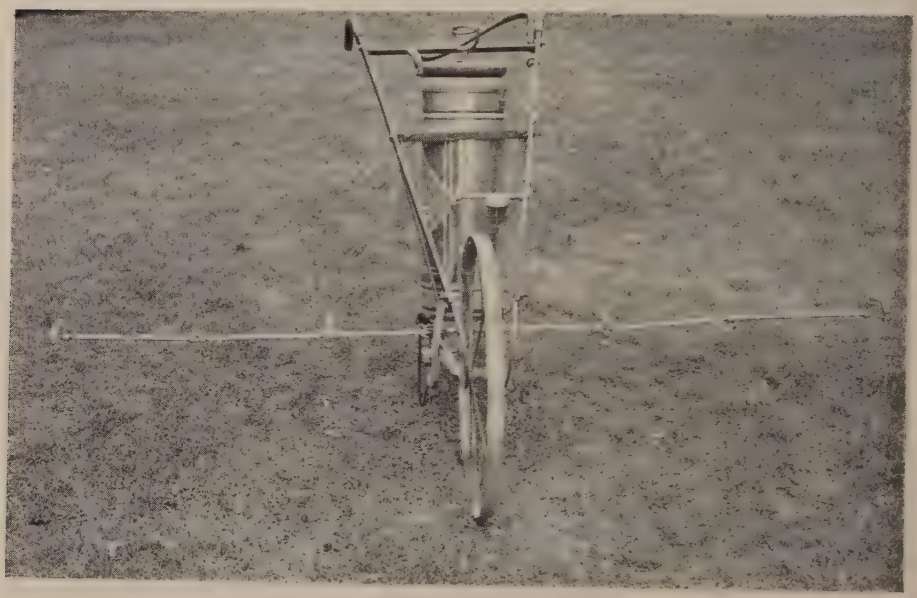

Fig. 4. Sprayer assembled with boom raised for spraying 2,4-D on lawns, golf courses, and the like.

EXPERIMENTAL FEEDING OF SULFATHIAZOLE SYRUP TO COLONIES OF BEES INFECTED WITH THE AMERICAN FOULBROOD DISEASE

By R. H. KELTY
SECTION OF HORTICULTURE

THE DISEASE known as American foulbrood is the cause of severe losses to beekeepers. The causal organism *(Bacillus larvae)* is a spore-former, capable of living for years in honey and combs in infected hives. It is carried in honey and on combs and hive equipment. Strong colonies "rob" honey from weaker diseased colonies and become infected with the disease. The beekeeper may spread the disease without realizing it by interchanging combs and hive parts from infected colonies to clean colonies. The disease is infectious, contagious and progressive. Ordinarily, infected colonies do not remove the diseased material from their combs and steadily become weaker and die during the winter following time of infection. Certain colonies of bees, apparently because of greater activity in "house cleaning," remove the diseased material and hold the disease in check for a time. But the disease is so difficult to control that experienced beekeepers usually kill the bees and sterilize the equipment in diseased colonies.

Since 1881, Michigan has had laws providing for inspection of apiaries, and since 1937 has prohibited the importation of bees on combs because of the danger of spreading foulbrood. The Apiary Inspection Bureau of the State Department of Agriculture has been required by law to burn diseased colonies when found, and by statewide apiary inspection has reduced the amount of foulbrood from a high point of from 40 to 60 percent diseased colonies in certain counties in the beginning to the present low point of 2.6 percent diseased colonies for the entire state in 1947.

The requirement that the Apiary Inspector burn colonies infected with the foulbrood disease when found has been very costly to many

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beekeepers, although the law enables the beekeeper to sterilize his equipment if he did the job before the bee inspector arrived.

Since 1941, the Bee Culture Laboratory of the U. S. Department of Agriculture has made studies of the effect of the so-called sulfa drugs and other materials, such as penicillin, upon the causal organism of American foulbrood *(Bacillus larvae)* in the laboratory but obtained no evident cure. On the other hand, the Missouri Agricultural Experiment Station and some other agencies have studied the effects of these drugs under apiary conditions and have obtained apparent temporary cures. Many beekeepers and some research workers have claimed that sulfathiazole did effect a cure for American foulbrood and that it was no longer necessary to burn colonies infected with American foulbrood.

July 11, 1945, the Michigan State Department of Agriculture requested the Michigan Agricultural Experiment Station to undertake experiments to determine what benefit sulfonamides may have in curing or controlling American foulbrood. It was decided to perform feeding tests under commercial apiary conditions.

PROCEDURE

Each colony in the experiment was provided with a division-board type feeder which remained in the colony throughout the experiment. The Missouri Agricultural Experiment Station reported apparent cure with a dosage of ½ gram sulfathiazole per gallon of sugar syrup and this dosage was used throughout the experiment. After the first feedings, it was found that sulfathiazole tablets were insoluble, much of the material settling out of the medicated syrup. Sulfathiazole sodium, which is soluble, was used during the remainder of the experiment.

The sugar syrup was made of three parts sugar to two parts of boiling water to which was added ½ gram sulfathiazole sodium for each gallon of syrup. The syrup was heated and stirred until complete solution was obtained as indicated by the clarity of the liquid.

In late July 1945, 21 colonies affected with American foulbrood were assembled at East Lansing for the experimental feeding. Sixteen of the 21 colonies were extra strong and lightly infected with the disease. The remaining five colonies were weaker and the disease was farther advanced. Each colony was fed approximately 3 quarts of the sulfathiazole syrup at 1-week intervals. The bees were gathering very little nectar and took the syrup readily.

After four feedings, visible evidence of American foulbrood had disappeared in nine of the strong colonies. A few scattered cells of disease remained in seven of the strong colonies. Four of the five badly diseased colonies showed marked improvement in cleaning out diseased material, while one colony showed little improvement.

After eight successive feedings, visible evidence of foulbrood had disappeared in the 16 strong colonies. They were considered strong enough to winter, and were given an additional 2 gallons of sulfathiazole syrup for winter food. Since the remaining five colonies were not considered strong enough to winter and had not removed all diseased cells, they were killed and the equipment was sterilized.

The 16 sulfathiazole-fed colonies lived over winter, and during the spring months of 1946, they were given five successive 3-quart feedings of sulfathiazole syrup at 1-week intervals from April 1 to May 6. No visible evidence of American foulbrood was observed in these colonies.

July 12, 1946, 35 lightly infected strong colonies were added to the experimental apiary. These colonies averaged approximately 40 pounds of honey per colony before being fed sulfathiazole syrup. The entire experimental apiary of 51 colonies was fed six successive 3-quart feedings of sulfathiazole syrup at 2-week intervals between July 12 and October 1, 1946. After three successive feedings, all of the 35 lightly infected strong colonies had removed all visible evidence of foulbrood, and the entire 51 experimental colonies seemed free from disease. Very little surplus honey was produced in the experimental apiary in 1946.

By October 14, all experimental colonies were considered strong enough for winter. Surplus honey from stronger colonies was given to other colonies needing winter food, and all colonies were given a last feeding of 3 quarts of sulfathiazole syrup.

During the winter of 1946-47, six experimental colonies died leaving approximately 30 pounds of food per colony. Twenty-five 3-pound package colonies were installed on May 6 on equipment from the experimental apiary, and the food from the six dead colonies was divided among the 25 package colonies. The package colonies were also fed three 3-quart feedings of sulfathiazole syrup at 3-day intervals for reserve food supply. Two package colonies became queenless and were united with queen-right experimental colonies. Five other queen-right package colonies were united with wintered-over

experimental colonies having failing queens, leaving a total of 63 colonies in the experimental apiary May 27, 1947.

The entire experimental apiary was fed four successive 3-quart feedings of sulfathiazole syrup from May 15 to June 26, 1947. No visible evidence of American foulbrood was seen in any of the experimental colonies during that period. All colonies were very strong with much brood. By July 1 no surplus honey had been gathered by the experimental colonies and prospects in the neighborhood were negative.

Since all colonies were very strong with no nectar in prospect locally, and since all colonies had been apparently free from disease all of the spring period, it was decided to move the 63 experimental colonies to two established apiaries in Tuscola County where considerable acreage of sweet clover promised a nectar flow. On July 7, 1947, the experimental colonies were moved from East Lansing to Tuscola County, 43 colonies being placed in an established apiary on Section 30-W, Elmwood Township and 20 colonies being placed in an established apiary on Section 27-S, Columbia Township. Both of these apiaries had been free from foulbrood on previous inspections.

No sulfathiazole syrup had been given to any of the experimental colonies since June 26, 1947, and it was desired to observe the effect of a nectar flow upon the experimental colonies.

On August 11, 1947, representatives of the State Apiary Inspection Service of the State Department of Agriculture, found 28 of the 43 experimental colonies lightly infected in the apiary on Section 30-W, Elmwood Township, and burned the colonies and sterlized the equipment. On August 13, 1947, the Apiary Inspectors found 13 of the 20 experimental colonies in the apiary on Section 27-S, Columbia Township, lightly infected and burned the colonies and sterilized the equipment.

It is likely that in the period June 26 to August 11-13 when no sulfathiazole syrup was fed to the experimental colonies during much of which period no nectar was being gathered by the bees, bees in the larval stage may have been fed diseased honey held in reserve in the hive during the experiment, which diseased honey fed in the absence of sulfathiazole syrup, caused a reappearance of foulbrood in the hives.

To date, no visible evidence of foulbrood has appeared in the remaining 22 experimental colonies, all of which were package bee colonies receiving 3 extra feedings of sulfathiazole syrup at installation time.

SUMMARY

Year	Number of experimental colonies	Number of 3-quart feedings of sulfathiazole syrup	Number of colonies apparently cured	Number of colonies destroyed in which disease reappeared
1945	21	8	16	5
1946	51	6–11	51	0
1947	63—package colonies wintered colonies	7 4	22 —	41 —

CONCLUSIONS

From this experiment it appears that the feeding of sulfathiazole syrup to strong colonies affected with American foulbrood may enable the colonies to remove visible evidence of the disease, provided the colonies are fed the sulfathiazole syrup continuously while bees are in the brood stage. It seems that the evidence of the disease may reappear if the feeding of the sulfathiazole syrup is discontinued, particularly if there is a reserve supply of diseased food in the hive.

JOURNAL ARTICLE ABSTRACTS

A Method for the Estimation of the Advancement of Vegetation by the Use of Daily Maximum Temperatures

PARTRIDGE, N. L.

Proc. Amer. Soc. Hort. Sci. 49: 7-14. 1947 [*Journal Article 714 (n. s.) from the Michigan Agricultural Experiment Station*]

Data comprising date of first bloom for peaches and daily maximum temperatures covering 24 seasons were used. Accumulations above various maximum temperatures ranging from 28° to 50° F. for periods beginning January 1, February 1, March 1 and April 1, respectively, and extending to the date of the first bloom of the peach, were calculated. The use of the coefficient of variability was an unsatisfactory measure of the approximation of the various indices to vegetation as indicated by peach bloom. A suitable means for evaluating the indices was determined, and it was concluded that the accumulation could be commenced January 1, February 1 or March 1 without changing significantly the value of the resulting index. There was also a wide range of maximum temperatures of approximately equal value for bases. The use of an index calculated from a maximum temperature base of 40° F. commencing January 1 was suggested for Michigan conditions. Tables calculated on this basis for 26 seasons are given to illustrate the variation between seasons, the assumption being that the progress of vegetation will be rather closely correlated with these indices.

Effect of Various Mulching Materials on Orchard Soils

TURK, L. M. AND PARTRIDGE, N. L.

Soil Science. 64 (2): 111-125. 1947 [*Journal Article 866 (n. s.) from the Michigan Agricultural Experiment Station*]

In the fall of 1939, an experiment, involving the use of lysimeters, was started for the purpose of studying the effect of different kinds of mulching materials on the accumulation of soil nitrates and the conservation of soil moisture. The surface soil (7 inches) of three soil types (Coloma sand, Hillsdale sandy loam, and Miami silt loam) was used, and mulches of alfalfa hay, straw, and straw plus ammonium sulfate were applied to each of the three soils; other lysimeters received no mulch. Additional mulches of peat, shredded corn stover, shredded corn stover plus ammonium sulfate, sawdust, shavings, and gravel were used on the Hillsdale sandy loam. Each treatment was made in triplicate and determinations were made of the quantity of water which percolated through the soils, the amount of nitrates produced, and the changes in exchangeable cations in the soils. With the exception of peat all mulches were effective in decreasing evaporation losses of water. The peat mulch had such a high absorptive capacity for water that with light rains or long intervals between rains very little water reached the soil. The quantity of nitrates produced in the unmulched soils was greater than in the mulched soils except where alfalfa was used in those soils which had received straw mulch plus ammonium sulfate. The decrease in

nitrate production under straw mulch and similar types of mulching materials is believed due to poorer aeration brought about primarily by a higher soil moisture content and to a somewhat lower temperature. In general, the least depressive effect on nitrate production occurred in the better aerated soil. Mulches such as alfalfa, straw, and corn stover contribute materially to the plant nutrient content of the soil.

Listerellosis in Sheep of Michigan

Gray, M. L., Thorp, F., Jr., Nelson, R. H., and Sholl, L. B.

M.S.C. Veterinarian. 7: 161-163. 1947 [*Journal Article 879 (n. s.) from the Michigan Agricultural Experiment Station*]

Four cases of Listerellosis in sheep have been confirmed by isolation and identification of *Listerella monocytogenes*. Three cases, two ewes and a lamb, occurred in the same flock and the fourth case in a nearby flock. The infection in the ewes was manifested by a central nervous system disorder, while the lamb displayed a typical septicemia. The cultures when injected intracerebrally into rabbits produced death in from 20 hours to 4 days. In all instances listerellae were isolated from the brain and liver. When instilled into the eyes of rabbits it produced a marked keratitis and conjunctivitis within 36 hours which persisted for 4 days.

Rumen Digestion Studies. I. A Method of Investigating Chemical Changes in the Rumen

Hale, E. B., Duncan, C. W., and Huffman, C. F.

Jour. Nutrition. 34 (6): 733-746. 1947 [*Journal Article 886 (n. s.) from the Michigan Agricultural Experiment Station*]

A critical appraisal of the lignin ratio method was made to obtain information on the rate of digestibility of various components in roughage. A theoretical and experimental basis for the calculation of the rumen digestion coefficients is presented. By the use of the suggested formulae, measurements can be made either of maximum digestion or the rate of rumen digestion. Lignin values form the basis of both of these procedures but are applied in two distinct ways. These methods are not suitable for determining digestion coefficients of mixed rations since concentrates are not only low in lignin but they also pass from the rumen more rapidly than roughages. The principles forming the basis for the rumen digestion calculations received special attention.

Rumen Digestion Studies. II. Studies in the Chemistry of Rumen Digestion

Hale, E. B., Duncan, C. W., and Huffman, C. F.

Journal of Nutrition. 34 (6): 747-758. 1947 [*Journal Article 887 (n. s.) from the Michigan Agricultural Experiment Station*]

Studies of the chemical changes in the bovine rumen show that during the first 6 hours after feeding there was rapid digestion of proteins and carbohydrates. The predominate phenomenon during the second 6 hours was a rapid disintegration of cellulose. The digestion of proteins and carbohydrates paralleled the digestion of cellulose. Rumen digestion came to a standstill within 12 hours after

feeding and prolonged digestion periods up to 24 hours did not increase rumen digestion coefficients. Average rumen digestion coefficients for 8 trials at 12-14 hours after feeding were: dry matter 48.4, protein 59.6, nitrogen-free extract 65.2, crude fiber 27.2, cellulose 43.4, other carbohydrates 83.0 and lignin 3.1 percent. After plant fragments pass from the rumen variable amounts of lignin may be digested, thereby exposing varying amounts of cellulose and protein to further digestion. The caecum plays only a supplementary role in the disintegration of roughage in the ruminant. An average of 11.6 percent of the cellulose and 9.5 percent of the protein was found to be digested in the caecum. The production of fatty acids in the rumen was demonstrated. Maximum increases, after the increase due to digestion was eliminated, were 54.9 percent on an alfalfa hay ration and 281.7 percent on a beet pulp ration. The rapid dissipation of fatty acids from the rumen, together with the marked synthesis, suggests that fatty acids make a highly significant contribution to the nutrition of the ruminant.

The Immunization of Guinea Pigs with Mucoid Phases of Brucella

HUDDLESON, I. F.

Am. Jour. Vet. Res. 8: 377-380. 1947 [*Journal Article 888 (n. s.) from the Michigan Agricultural Experiment Station*]

When live cell suspensions of certain mucoid growth phases of *Brucella suis* and *Brucella melitensis* were prepared in a suitable concentration and injected into normal guinea pigs, they were capable of engendering a high degree of active immunity against experimental infection with all three species of Brucella.

Cell suspensions of *Br. suis*, M. phase 2, after irradiation with ultraviolet light to a sufficient degree to render all but a few cells in a 1-mg. dose nonviable, were also capable of producing a high degree of immunity in guinea pigs against experimental infection with *Br. suis* and *Br. melitensis*.

The vaccine-treated guinea pigs that were found free from infection after exposure did not show specific agglutinins in the blood serum in dilutions of 1:25 or above.

The results of the experiments reported herein suggest the possibility of obtaining a high degree of immunity with this type of Brucella vaccine against brucellosis in animals and human beings.

Cannibalism and Feather Picking in Chicks as Influenced by Certain Changes in a Specific Ration

SCHAIBLE, P. J., DAVIDSON, J. A., AND BANDEMER, S. L.

Poultry Science. 26 (6): 651-656. 1947 [*Journal Article 890 (n. s.) from the Michigan Agricultural Experiment Station*]

The vicious habit of picking feathers, comb, wings, toes, tails, vent, and other parts of the body of the chicken is one of the serious problems of keeping poultry in confinement. Environmental factors as well as nutrition involving various management procedures have been cited as the causes of this habit.

A basal ration containing a high percentage of yellow corn and a low content of protein, phosphorus and fiber produced a high incidence of cannibalism and feather picking in chicks started in a chick-starting battery. Various ingredients were added to the basal ration and the difference in cannibalism and

feather picking noted. These ingredients included inorganic supplements, including different calcium compounds and sodium compounds, several sources of fiber, and various protein supplements.

Certain of the protein supplements seemed to be more effective than others, with casein being the principal ingredient which at various levels reduced the amount of picking and cannibalism. At a 2-percent level, casein reduced cannibalism and improved feathering while 3.6 percent was required to reduce feather picking.

The time of year is not an important factor. The results of these experiments indicate that malnutrition may of itself result in feather picking and cannibalism in White Leghorn chicks.

The Amino Acid Composition of Bovine Semen

RAY SARKER, B. C., LUECKE, R. W., AND DUNCAN, C. W.

Jour. Biol. Chem. 171 (2): 463-467. 1947 [Journal Article 893 (n. s.) from the Michigan Agricultural Experiment Station]

An amino acid analysis of a composite of 149 semen samples obtained from 40 different bulls is reported. These bulls were used routinely for artificial insemination and were of the Holstein, Guernsey, and Jersey breeds. The semen was centrifuged at 5,000 r.p.m. and the sperm separated from the seminal plasma. The sperm and seminal plasma were frozen and dried in this state by sublimination. The concentration of 11 amino acids in the sperm and seminal plasma is reported. With the exception of arginine, leucine, and tryptophan, the amino acid composition of sperm and seminal plasma is quite similar. The arginine content of sperm is very high but is relatively much lower in seminal plasma. The tryptophan concentration in seminal plasma is considerably higher than that found in sperm.

Heavy Minerals in Some Podzol Soil Profiles in Michigan

MATELSKI, R. P. AND TURK, L. M.

Soil Science. 46: 469-487. 1947 [Journal Article 898 (n. s.) from the Michigan Agricultural Experiment Station]

A study was made of heavy minerals in some of the northern Michigan podzol profiles in order to aid in explaining certain morphological peculiarities in these soils. It was thought that such a study would aid in revealing geological differences in the soil horizons and in determining the intensity of the weathering processes in various horizons. Two groups of podzol soils were investigated; namely, Emmet, Kalkaska, and Wallace sands, designated as group I; and Grayling, Rubicon, Roselawn, and Eastport sands, designated as group II. Members of group I were characterized by a stronger expression of the Morphological features of typical podzol profiles than were members of group II. Heavy mineral separations were made on the fine sands and there were significantly greater amounts of heavy minerals in all horizons of the group I soils than in the corresponding horizons of the group II soils. In all the soils, the total amount of heavy minerals was greatest in the C Horizon. In most of the soils, the B Horizon had the lowest content of heavy minerals. The brown B Horizon of these podzols is the result of a vigorous decomposition of a relatively high original content of opaque and ferromagnesian minerals. Organic matter is an effective weathering

agent of some heavy minerals in the B Horizons. The least resistant mineral to podzol weathering was found to be dark green hornblende, followed by grey-green hornblende, the opaque minerals, and the garnets. In general, the B Horizons suffered a greater decomposition of the heavy minerals than did the A or C Horizons. Kalkaska and Emmet sands (soils that support a hardwood cover) contained a greater quantity of calcium and magnesium heavy minerals in all horizons of the profile than did Wallace, Rubicon, Roselawn and Grayling sands (soils that support a pine cover). The data suggest that the intense brown B Horizon in group I soils is due to a greater amount of iron oxide, organic matter and perhaps to a greater orginal content of the opaque and ferromagnesian minerals (and of the greater decomposition of these minerals) than in the group II soils.

The Detection and Correction of Bacterial Contamination of Milk Bottles in a Bottle Washer

BRYAN, C. S., BORTREE, A. L., AND LUCAS, P. S.

Jour. Milk Food Tech. 10 (6): 319-322. 1947 [*Journal Article 899 (n. s.) from the Michigan Agricultural Experiment Station*]

An instance of bottle washer contamination of milk bottles from a crate washer is described. Physically-clean milk bottles yielded bacteria counts up to 94,000 per quart bottle when this should be no more than 1,000 and usually 200 or less. Chlorination, as the final treatment in the bottle washer, yielded satisfactory bottles, although the contamination continued at the inside rinses. The installation of a vacuum breaker on the water line between the bottle washer and the crate washer corrected the combination problem. The data presented emphasize the importance of proper installation of case and bottle washers.

Blood Studies in Dogs Following the Injection of Penicillin

BRINKER, W. O.

North American Veterinarian. 25: 31-33. 1947 [*Journal Article 909 (n. s.) from the Michigan Agricultural Experiment Station*]

Penicillin was administered in various vehicles, dosages, and routes of injection to determine (1) the blood plasma levels of penicillin at different intervals following its administration, and (2) the effect on the peripheral blood. Seventy-one trials were completed, using 12 normal, healthy dogs.

Following a single injection of 1,000 units per pound of body weight in a vehicle consisting of 5-percent dextrose in physiological saline, the penicillin blood plasma concentration was found to be approximately the same for all four routes of injection at 30 minutes; however, the penicillin level of 0.03 unit or better was maintained approximately twice as long when the subcutaneous, intramuscular, and intraperitoneal routes were used as compared to the intravenous route.

Penicillin blood plasma levels following the administration of various doses (250, 500 and 1,000 units per pound of body weight) in 5-percent dextrose and physiological saline given intramuscularly and subcutaneously were studied. In this series of trials the resulting levels following subcutaneous administration were found to be slightly superior to those following intramuscular administration both in concentration and prolongation of plasma level.

When administered subcutaneously, 5-percent dextrose in physiological saline was found to be equal or slightly superior to the water-in-oil in maintaining penicillin plasma levels. Romansky's Formula was found to excell the above vehicles, as a level of 0.03 unit or better was maintained in all cases at least 6.5 hours following a subcutaneous injection of 1,000 units per pound.

In each trial the first and last blood sample drawn was checked for erythrocyte and leukocyte cell counts, hemoglobin content, and leukocyte differential count. These data indicate that single injections of penicillin in various dosages have no immediate effect on altering the peripheral blood in the normal healthy dog.

The subcutaneous route of injection was found to be the one choice for ease of administration, least objection on the part of the dogs, and for production and prolongation of the penicillin blood plasma level. No local or systemic reactions were noted following the injection of the various penicillin preparations used in this experiment. On autopsy of the dogs at the termination of the study no macroscopic lesions were found at the sites of injections.

Shrinkage of Spun Rayons in Hand and Machine Laundering

TEAR, J. F.

Rayon Textile Monthly. 28 (9): 83-86. 1947 [*Journal Article 910 (n. s.) from the Michigan Agricultural Experiment Station*]

In recent years, rayon, and particularly spun rayon, fabrics have replaced cottons for women's wash dresses, for sport wear and children's clothing. One difficulty with rayons and especially spun rayons has been dimensional change, the shrinking and stretching of fabrics. The purpose of this study was to determine the amount of dimensional change in a selected group of spun rayons when laundered by hand and by machine. The 37 spun rayons tested were purchased in Michigan in the spring of 1944.

The fabrics that were hand laundered retained their original texture and appearance better than those laundered by machine. The latter looked as though they had been washed and ravelled very badly.

There was no appreciable difference in the amount of shrinkage that occurred in the hand laundered and the machine laundered, most of them shrinking 5 percent or more. This amount of shrinkage is so high that any garments made from these fabrics would in all probability be unsatisfactory after laundering.

A Chemical Control of Seedstalk Development in Celery

WITTWER, S. H., COULTER, L. L., AND CAROLUS, R. L.

Science. 106 (2763): 590. 1947 [*Journal Article 913 (n. s.) from the Michigan Agricultural Experiment Station*]

Premature seeding of celery (variety, Cornell 19) was prevented by spraying the young seedlings, prior to cold exposure and field transplanting, with 100 parts per million of alpha-ortho-chlorophenoxypropionic acid. All plants sprayed with the chemical, whether subsequently exposed to cold or not, remained vegetative throughout the growing season. Similarly handled but unsprayed seedlings produced seedstalks.

Evaluation of Some Poultry Remedies

STAFSETH, H. J.

M.S.C. Veterinarian. 8 (11): 56-64, 86. 1948 [*Journal Article 931 (n. s.) from the Michigan Agricultural Experiment Station*]

This work was done at the request of the Food and Drug Administration, Washington, D. C. The purpose was to determine whether certain claims made concerning these "remedies" were true. Millions of dollars are spent by poultrymen throughout the country for worthless remedies, some of which are actually harmful when used under given conditions. The "remedies" concerned were tested under controlled condition *in vivo* and *in vitro* with the following results:

None of the experiments here reported revealed any evidence justifying the use of any of the remedies tested. They proved to be perfectly worthless; in fact, GM appears to be harmful when given to chickens and chicks affected with pullorum disease.

Medication with the "remedies" employed in these experiments did not materially affect appetite, water consumption or body weight.

So-called intestinal astringents were tested for astringency, coagulation of protein. No results were obtained that would justify their use as "intestinal astringents".

The products recommended as antiseptics to be used in drinking water, when subjected to phenol coefficient and agar cup tests, proved to be entirely worthless.

If potassium dichromate has any value in the medication of poultry, as is thought to be the case in the treatment of pullet disease, (Weisner, 1940, and Jungherr and Matterson, 1944) there is certainly no evidence supporting any claims of astringent or antiseptic action in the recommended dosage. This is also true for the other products recommended for use in drinking water and tested in the course of these experiments.

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